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ON

TREATMENT, MEDICINE, SURGERY, NEUROLOGY, PÆDIATRICS, OBSTETRICS, GYNÆCOLOGY, ORTHOPÆDICS, PATHOLOGY, DERMATOLOGY, OPHTHALMOLOGY, OTOLOGY, RHINOLOGY, LARYNGOLOGY, HYGIENE, AND OTHER TOPICS OF INTEREST TO STUDENTS AND PRACTITIONERS

BY LEADING MEMBERS OF THE MEDICAL PROFESSION THROUGHOUT THE WORLD

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Diagnosis and Treatment

THERAPEUTIC APPLICATION OF MECHANICAL VIBRATION

BY MARY L. H. ARNOLD SNOW, M.D.
New York City

Mechanical vibration in therapeutics is a subject of great importance—a potent agent in the hands of a skilled clinician. The vibrator is to be employed, not as a suggestive agent, nor as an instrument to be run up and down the back or quickly over a part for spectacular effects, but is to be used with scientific skill and discreet judgment for the purpose of producing definite effects, and the relief or cure of functional derangements.

Mechanical vibration is applicable to a particular class of cases; viz., those which have brought prestige to massage, osteopathy, or cheiropraxy. Therapeutically it presents for consideration two fields, —diagnosis and treatment,—and is employed for effects upon the spine and as vibra-massage.

The essentials of a desirable vibrator are as follows: It should not easily get out of repair, and should be so constructed as not to injure or soil the patient's clothing. The vibrations should be of uniform quality, ranging from weak to strong. The force of impulse or stroke and the rate or speed should be variable and under control. The vibrator should be one easily moved about and easily operated, and readily adapted for application to all parts of the patient to be treated. Weight and excess of transmitted vibration to the operator are objectionable.

Locally the vibrator in operation assists in determining (1) the presence and site of inflammation and pain, and whether the pain is local, or reflex, or associated with a diseased viscus or nerve-trunk; (2) the presence and degree of muscular spasm in a part; (3) the degree of tissue irritability; (4) the range of mobility in a joint

by the induction of lessened tension; and (5) the state and degree of reflex efficiency.

Examination of the spine with the vibrator is a valuable aid to diagnosis. After noting physical peculiarities by inspection and palpation with the patient both sitting and lying down, place the patient in the prone position, and with the ball vibratode applied to the intervertebral spaces examine the spine for points of tenderness, then with the disk vibratode examine the muscles of the back for contractions or local muscular tension.

Some of the landmarks of the spine for localization are the *second cervical vertebra,* felt in the pit of the neck by pressure; the *seventh cervical,* the vertebra prominens, which is brought into prominence by the patient bending his head forward and folding his arms; the *third dorsal,* which is on a level with the commencement of the spine of the scapula, a dimple marking the root of the spine; the *seventh dorsal,* corresponding with the head of the last rib; and the *fourth lumbar,* which is on a level with the highest part of the ilium.

Examination of the spine by intervertebral vibration is accomplished as follows: When the upper part of the body only is vibrated it is more convenient to have the patient sit up, because the spines are more readily discerned, but when making application to the whole spine or lower than the seventh dorsal it is better to have the patient lie prone on a fairly hard table which offers some resistance, the arms of the patient hanging down at either side to allow muscular relaxation and a wider interscapular space. Intervertebral vibration, unless prolonged—in which case the resultant friction is objectionable—may be administered over the undervest. If vibration is applied to the intervertebral spaces as treatment the duration should vary from 3 to 15 minutes, according to the condition treated and effect sought, with short rest intervals. Care must be exercised not to produce undue irritation,—the result of friction.

Intervertebral vibration is administered by placing the second and first finger-tips of the left hand on two contiguous spinal processes, holding the ball vibratode in the intervertebral space between the processes with the right hand, and making the application first on the right side and then on the left, raising the index-finger of the left hand out of the way when changing the vibratode from the right to the left side, the second finger of the left hand remaining

in position. The first finger is then placed on the same spinal process as before, and the second finger moved to the site occupied by the first, which is then raised to seek the spinous process of the next vertebra. The thumb and index-finger are thus always ready to steady the vibratode and prevent it from rebounding or to mitigate the severity of the vibration over a thinly-covered surface. At the same time the first and second fingers afford, by the sense of touch, a means of determining the intensity which is essential to a skilful vibratory technic, the neglect of which is the principal objection justly raised by some advocates of massage to mechanical vibration.

When used either for treatment or diagnosis, vibratory interruption, vibratory stroking, or vibratory friction is employed.

Vibratory stroking consists in lightly touching the surface of the body with a vibratode, preferably a rubber-covered disk, and moving it over the surface in the direction indicated. It is applied to skin areas for its soothing effect or for the induction of reflex effects, and is indicated where there is a lack of muscular tone in the area; stimulation of the reflexes will induce contraction and increase the tonicity of the parts.

Vibratory friction is applied by moving the vibratode, preferably a rubber-covered disk, with varying degrees of speed and pressure suited to the particular part or condition to be treated. It is employed with three ends in view: (1) *Centripetally*—toward the heart—for increasing the flow of lymph, blood, and chyle in that direction, thus promoting absorption; (2) *centrifugally*—away from the heart—to retard such activities, and for its soothing and derivative effects upon certain organs; (3) *circularly*, the advantage of which lies in its adaptation to particular parts treated.

Certain principles of technic are important for the effective application of mechanical vibration:

(I.) Vibration should be given with such speed as is applicable to the condition to be treated; and the length of stroke should also be adapted to the density and depth of the part or tissue.

(II.) Exerted pressure should cause no pain unless it be due to local infiltration, degeneration, or muscular spasm, when the operator should be guided by the patient's tolerance and the effects sought.

(III.) The rapidity of stroke and degree of pressure should be governed by the indications and the patient's reactionary resistance.

(IV.) Overstimulation should be avoided in order not to exhaust the nerve force.

(V.) Vibration should be applied to a part or to its nerve-roots to promote or increase the functional activity without altering in tegrity. The effect will vary directly or indirectly with the duration, speed, direction, stroke, and pressure.

When applying vibration for the purpose of diagnosis the duration of contact is usually short; whereas, for treatment it may be either of short or long duration, according to the effects desired. When examining an organ for tenderness, apply interrupted vibration with the disk vibratode with varying degrees of pressure, and test the degree of congestion or spasm by the patient's tolerance. A sensitive gall-bladder, stomach, liver, or spleen is easily diagnosed by mechanical vibration of the part. Sensitive areas on the surface correspond to the spinal segments from which the posterior roots take their origin or to the points of exit of the affected spinal nerves. The following observations by Reed in regard to autonomic pain are of interest in this connection:

"1. Visceral pain, although due to pressure when the abdomen, pelvis, and thorax are concerned, is expressed chiefly but not exclusively in the autonomic analgesic areas of the protective walls, corresponding in extent with the peripheral distributions of the respective spinal nerves in the muscles and subserous connective tissue.

"2. These distributions can generally be determined clinically by determining the area of partial hyperalgesia.

"3. The pain itself, consisting chiefly of hyperexcitation of muscle irritability, can be partially and, as a rule, entirely inhibited by inhibiting the muscle sensibility in the hyperalgesic areas."

The muscles should be examined for response and tension, and it should also be noted whether the effect produced is local or reflex, and whether the examination induces pain or contraction in other parts. A hard ball vibratode, approximately three-fourths of an inch in diameter, is used for the spinal examination, and a rubber-covered, slightly convex disk elsewhere, unless the part be hypersensitive, when a soft rubber, cup-shaped vibratode should be used.

The correct interpretation of elicited tenderness is as important and technical as the interpretation of an X-ray plate. The operator should always note whether the tenderness or pain elicited be real or simulated. The taking of the pulse-rate before, during, and after vibration may sometimes be necessary. If the pulse-rate is increased after the application it denotes genuine pain. Loewi's sign—increase in the dilatation of the pupils in proportion to the intensity of the pain—is also of value, and may serve as a guide.

When tenderness is elicited the pain may cause contraction in a remote part associated by nerve connections, as an overstrained muscle may cause a spinal tenderness through its nerve supply, and reflexly induce pyloric spasm through the association of the sympathetic nerve supply of the stomach with the spinal nerve supply of the muscle.

Tenderness, therefore, corresponding to an associated viscus, is an indication for vibration of the viscus as well, to ascertain if it also be tender, which, if so, would indicate a local affection of the organ.

A spinal examination may reveal local as well as reflex tenderness. Tenderness in the cervical or upper dorsal region is often associated with neuritis in the neck, shoulders, or arms. When in the dorsal region it may be referred to the chest, or to some organic disorder as of the stomach or liver; tenderness over the dorsolumbar region refers to the leg or foot, and of the lumbar region to the lower limbs. In the study of many cases of brachial neuritis the writer has noted pain more often at the points of exit of the brachial nerves than at their sites of origin. This can often be relieved by vibration over the seat of the affection with the ball vibratode.

In pseudo states spinal or local mechanical vibration relaxes the spasm and dissipates the trouble, thereby revealing the true nature of the condition.

Besides the referred spinal tenderness so often observed during recent years, Cyriax and the writer have had their attention called to pain referred to special nerves and associated with pathological conditions of certain viscera; for instance, when the lungs and bronchi are affected there is an associated interscapular tenderness. In some affections of the liver and gall-bladder the sixth, seventh, tenth, and eleventh dorsal nerves on the right side are sensitive. In

stomach derangements the sixth, seventh, and eighth dorsal nerves of the left side are affected and sensitive. In uterine affections the third sacral nerves are tender.

In differential diagnosis vibration occupies an important place, as in differentiating the pain of intercostal neuralgia from the tenderness of visceral affections. The elicitation of bilateral pain in the sciatic region points to an abnormal interpelvic condition, as prostatitis or a fibroid tumor. In the latter case vibratory treatment for the relief of pain due to the internal condition would be of little avail. Mechanical vibration, therefore, when used for diagnosis, oftentimes reveals conditions which are not amenable to vibratory treatment. The findings sometimes materially modify the prognosis; as, for instance, in a case of suspected sciatica, when spinal tenderness elicited in the lumbosacral region shows lumbosacral cord involvement.

Aside from its value as a diagnostic agent, mechanical vibration opens up an important field in therapeutics. The heart, aorta, stomach, liver, or spleen may be made to contract or dilate at the will of the operator, producing effects available for the correction of impaired functions.

To Dr. Albert Abrams, who has done much to place spinal therapeutics on a scientific basis, the medical profession is greatly indebted. In pioneer work he discovered definite guide-posts to direct the clinician to special organs of the body. He employs the concussional method in the treatment of local conditions. With due respect to him, however, and all honor for the wonderful work that he has accomplished, the writer believes that the same phenomena will result from the application of various other stimuli when applied at the sites he has discovered and indicated for the correction of various pathological or functional conditions which he has treated. Their comparative merits are yet to be determined.

Through the kindness and courtesy of Dr. Anthony Bassler, of New York City, I have been permitted to study some pathological conditions by means of the X-rays. These changes induced by vibration have been previously only studied clinically, so far as I know. They are here put on record, with remarks on the interpretations of the skiagrams.

FIG. 1

Hypertrophied heart before vibration. (Case I.)

FIG. 2

Hypertrophied heart after vibration. (Case I.)

Fig. 3.

Aortic aneurism before vibration. (Case II.)

Fig. 4.

Aortic aneurism after vibration. (Case II.)

CASE I.—Mr. T. is a patient subject to attacks of violent tachycardia. An effort was made to control this by inducing reflex contraction of the heart. To demonstrate what had been accomplished by vibration the patient was stripped to the waist, and while lying prone upon the table the first X-ray picture was taken, showing his heart. As quickly as possible, the patient remaining in the same position, vibration was administered for three minutes with a hard ball vibratode placed between the seventh cervical and first dorsal vertebræ, immediately after which a second X-ray picture was taken. The most important change revealed in the second picture was in the shape of the heart, which was more globular, indicating better tone. On measuring the transverse diameter from the right auricle to the apex it showed a shortening of one-fourth of an inch; from the aorta to a point on the other margin of the heart directly below, there was a difference in the two pictures of one-half of an inch. There was also a shortening of the ventricles, the heart was smaller, and more globular in form. This reflex contraction of the heart is sometimes induced by a ten-minute vibratory treatment with intervals of rest; but, when applied to patients for the purpose of toning up the heart, we have usually administered it for one and a half to two minutes. We found that a longer vibratory treatment apparently produced undesirable temporary symptoms, such as a heart cough, usually accompanied by a sense of dryness in the nasal passages. (Figs. 1 and 2.)

CASE II.—Mrs. B. This patient presented an immense aneurism, and, as she could not lie down comfortably, skiagrams were taken in the upright position, and she was also vibrated in this posture. Immediately after the first X-ray exposure she was vibrated on each side alternately for five minutes with the ball vibratode between the seventh cervical and first dorsal vertebræ. The transverse diameters of the ribs in the two pictures were exactly the same. This is important, in her case particularly, as her shoulders were so rounded that it was impossible for her to lean back flat against the screen. The picture taken after treatment showed a noticeable change in the size of the aorta. The widest measurement was the same in each—six and one-fourth inches. Taking the measurements at the second rib above, the picture taken before treatment was five inches across, whereas after treatment it was four and a half inches. The diameter near the lower border of the picture was six inches in the first picture, whereas after treatment the measurement was five and three-fourths inches. This demonstrated satisfactorily that an aortic aneurism could be contracted by means of mechanical vibration applied between the seventh cervical and first dorsal vertebræ. Whether concussional treatment at the same site, or heavier vibratory treatment, or treatment with a vibrator of different stroke, or vibratory treatment of longer duration, would have produced better results are questions yet to be answered. The marked relief afforded the patient by these administrations was additional clinical evidence of a reduction in the dimensions of the aneurism. (Figs. 3 and 4.)

CASE III.—Mrs. F. presented an hypertrophied heart. It was treated by a five-minute prolonged interrupted vibration between the seventh cervical and first dorsal vertebræ with the following result:

The heart changed its location in the chest, as shown in the skiagram, and its shape, also, was altered. The greatest difference transversely was in the upper part. The length of exposure in each instance was three seconds, or a

period in which the heart would have passed through more than two cycles. (Figs. 5 and 6.)

CASE IV.—Mrs. S., a patient who had had a dilated stomach. After taking the usual bismuth dose an X-ray picture was procured. This was followed by a vibratory application lasting ten minutes, during which the ball vibratode was placed alternately on each side of the spine in the intervertebral spaces between the first and second, and second and third lumbar vertebræ; immediately afterward a second picture was taken. Usually the stomach holds the bismuth for approximately half an hour, but in this case some of the bismuth had already passed into the duodenum, which showed increased motility. The contour of the stomach had changed, and its position was a half inch higher after the vibratory treatment. It was also interesting to note that the upper border of the liver in the same picture showed a contraction of three eighths of an inch. These cases suggest possibilities in therapeutics. (Figs. 7 and 8.)

The heart-reflex of contraction (so called by Abrams) is indicated (1) when there is myocardial insufficiency; (2) relative valvular insufficiency; (3) myocarditis; (4) overstrained heart; (5) hypertrophied heart; (6) a condition requiring prolonged muscular exertion which acts on the blood-vessels; (7) dilatation when due to a weakened wall which yields to a normal distending force.

The efficiency of mechanical vibration in the treatment of some cases of high blood-pressure is remarkable. In the study of arterial tension two conditions are recognized: (1) A weak heart associated with high blood-pressure in which the vasoconstrictor mechanism is not compensated for, and (2) a high blood-pressure dependent upon dilatation of the splanchnic vessels and engorgement of the liver, as evidenced by increased areas of dulness and marked functional derangements.

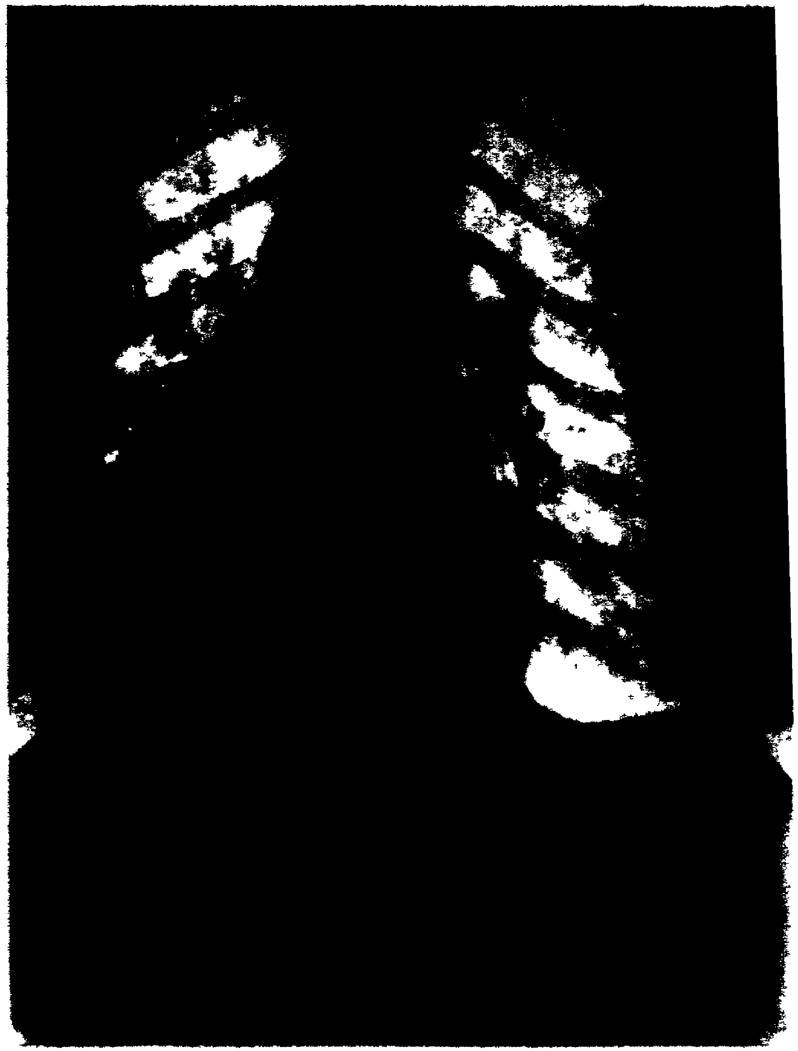
Blood-pressure may be lowered (1) by cardiac inhibition (vagal stimulation), when it falls suddenly; (2) by stimulation of the depressor, when the fall is gradual; (3) by depressing the sympathetic centre; (4) by inhibiting the functional activity of the vasomotor centre; (5) by afferent nerve stimulation, by inducing contraction of dilated splanchnic and abdominal vessels, or by disengorging the liver.

How vibration lowers the blood-pressure is a question for laboratory investigation. Bradford and Dean note that filament nerves [illegible] with the spinal nerves "from the second to the sixth dorsal, and maximum effects are obtained on a level with the third, fourth, [illegible] dorsal nerves, which cause [illegible] vasoconstriction and

FIG 5.

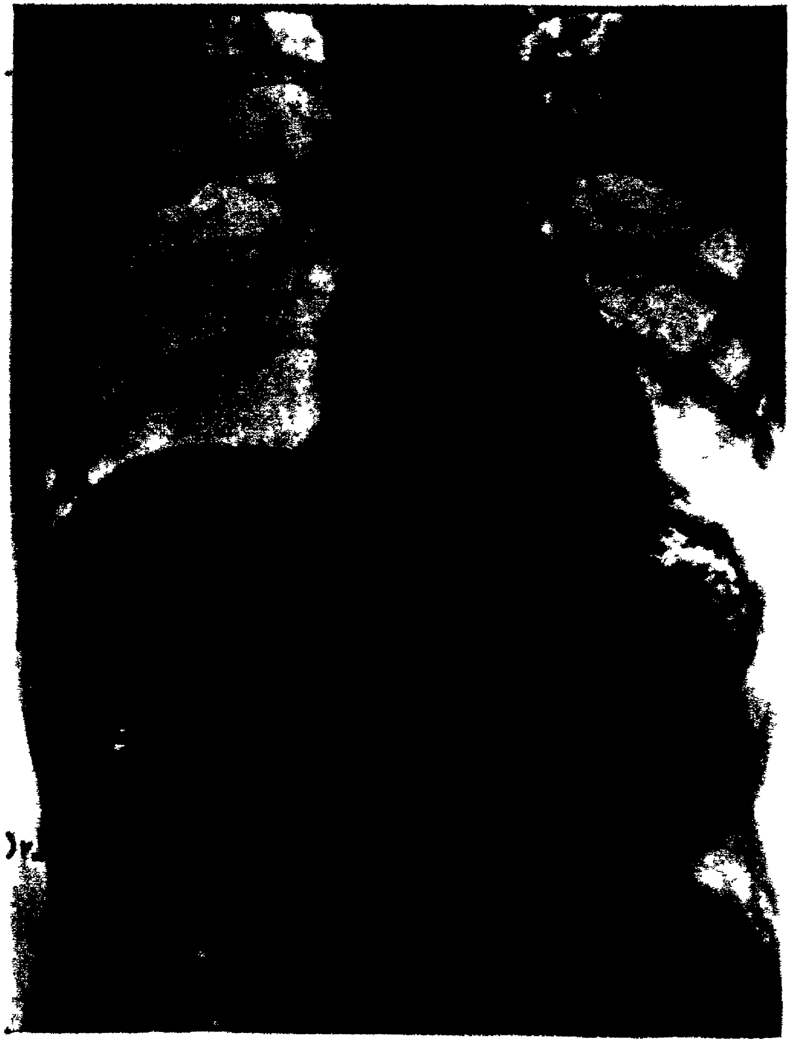
Hypertrophied heart before vibration (Case III.)

FIG. 6.



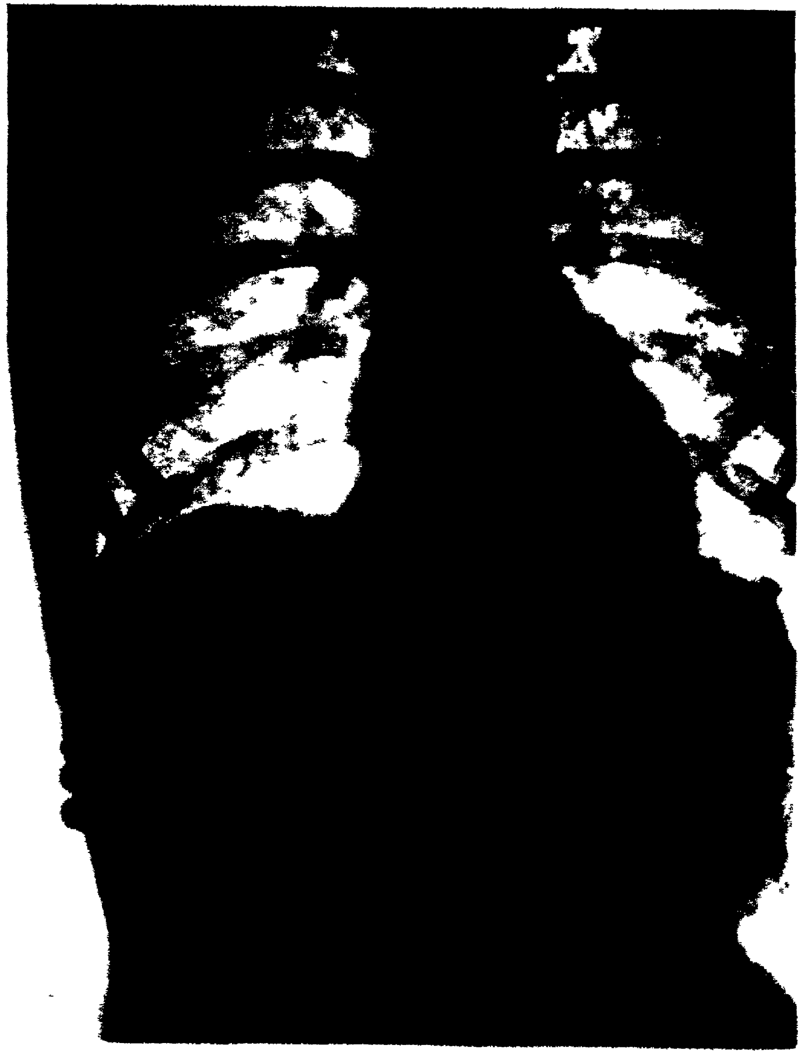
Hypertrophied heart after vibration. (Case III.)

Fig. 7.



Stomach after bismuth meal before operation Case IV

Fig. 8.



Stomach after bismuth meal following operation Case IV

a fall of blood-pressure." Morris in his investigations found the highest point of origin of the second dorsal to be the lower border of the second thoracic vertebra, and the lowest origin of the fifth dorsal at the junction of the upper one-fourth and lower three-fourths of the spine of the fourth thoracic vertebra.

In our experience, the heart-beat is usually lowered with a lowered blood-pressure, but occasionally it is increased. Foster believes that if the heart-beat is not markedly changed with a lowered blood-pressure the fall of pressure must be due "to the diminution of peripheral resistance, occasioned by the dilatation of some arteries." According to Butler, "a decreased heart-rate may be due to pneumogastric irritation or paralysis of the cardiac sympathetic nerves and ganglia," and that "an increased frequency of pulse may be due to paralysis of the pneumogastric or irritation of the sympathetic nerves or the intracardiac ganglia." Kirke found that in a frog the site of stimulation and the intensity of the stimulus applied to the vagus determined the effects produced,—inhibition or increased activity. A few accelerating fibres reach the heart by means of the vagus, and when they are stimulated the heart-beat is accelerated or strengthened, or the latter alone happens. The excitability of the inhibitory vagus fibres is exhausted more quickly than that of the accelerating fibres, "but the vagus fibres are more excitable than those of the accelerans." Landois and Sterling state that if the nervus accelerans is stimulated a long latent period occurs before the frequency of the heart-beat is affected. If the vagus and accelerans fibres are stimulated at the same time, only the inhibitory action of the vagus is induced. If, during the stimulation of the accelerans, the vagus is suddenly stimulated, a reduction occurs in the number of heart-beats, but if the vagus stimulation ceases an accelerating effect is again noted (C. Ludwig with Schmiedeberg, Bowditch, Baxt.). Cyriax states that heart vibration acts by assisting in restoring the normal equilibrium between the augmentor and inhibitory fibres which has been disturbed by diminished or increased excitability of either of them.

The indications to be met in the treatment of high blood-pressure due to arteriosclerosis are (1) to reduce the waste-products; (2) to counteract the morbid processes by drugs or physical measures which affect the depressor nerve and cause "constriction of the arterioles through which the anterior pituitary and the thyroid apparatus are

supplied with blood. The supply of adrenoxidase (besides thyroidase) being diminished, the metabolic activity of the vascular walls is reduced, and the chief pathogenic process is controlled."

In the treatment of aortic aneurism, first percuss the patient at the level of the manubrium. If the dulness exceeds 5 cm., a dilated aorta is present. Apply prolonged interrupted vibration alternately on each side of the spine between the seventh cervical and first dorsal vertebræ for five minutes or less, after which the patient will invariably say that he feels better, or "lighter," as he expresses it, and that he can breathe with less effort.

Among the most interesting cases in the study of blood pressure are those of *splanchnic neurasthenia* (Abrams) characterized by a reversal in the normal relation of tension when lying down and sitting. The pressure is higher when lying down than when sitting, and usually the pulse-rate is found to be more rapid than normal, being rarely, if ever, below normal, while at the same time, as a rule, the proper relation between the postural pulses is not maintained. These patients suffer from a congested liver associated with gaseous accumulations, either with or without abdominal tenderness, and with distention of the abdominal blood-vessels. The blood-pressure may or may not be characterized as high; in fact, in the majority of cases it has been below 120 mm. The most prominent symptoms which these patients manifest are weakness, marked inability to make either mental or physical effort without great fatigue, and mental vagaries with loss of interest in life. They may speak of dizziness or syncope, and may have attacks of vertigo or temporary visual disturbances, but usually complain of no physical ailment, oftentimes have even no pain. Unless due attention is paid to the patient's blood-pressure and pulse-rate, lying down and sitting, treatment will not reach the existing pathognomonic conditions.

The cause of the trouble is the inability of the nerves controlling the lumen of the blood-vessels properly to perform their functions. Consequently the vessels lacking proper tone, the splanchnic blood-vessels, do not contract properly, nor preserve the normal balance in the distribution of the blood. The lessened rapidity of the blood-flow results in lessened functional activity with resulting diminution of power, physical and mental. These patients also show the exaggerated cardio-splanchnic phenomenon demonstrated by Abrams;

viz., when the lower part of the sternum contiguous to the heart is percussed it normally yields a resonant or hyperresonant note. If the patient then reclines, and the stomach be compressed or vibrated, the same area when percussed will yield a dull or flat note—the cardio-splanchnic phenomenon. In splanchnic neurasthenia the area of dulness is increased.

As these symptoms are caused by lack of tone of the vasomotors, the indication is to increase their tonicity and thereby contract the splanchnic vessels, with the result that intra-abdominal congestion is lessened. Associated stasis and relaxation of abdominal parts, if present, are relieved. This may be accomplished by intervertebral vibration with the ball vibratode applied in the intervertebral spaces from the second to the fifth dorsal vertebra for five minutes, exerting just enough pressure to steady the vibratode unless the patient is extremely stout, when more pressure is required. The speed of the machine should be rather slow.

When there is cardiac insufficiency, apply the ball vibratode between the seventh cervical and first dorsal vertebræ for one and a half to two minutes. This method will frequently reverse both the tension and pulse at the first application, and lower the rate of both if above normal.

Abrams's method of testing for cardiac insufficiency is interesting. It is accomplished by comparing the blood-pressure taken before and after the precordial region has been lightly struck with a pneumatic hammer. If the pressure last taken shows a noticeable increase the myocardia is strong, if a noticeable decrease the myocardia is weak. If the difference is but a few millimetres there is myocardial sufficiency. If a patient has no myocardial insufficiency his tension will be lowered by vibrating from the second to the fourth dorsal. If there is myocardial insufficiency vibration between the seventh cervical and the first dorsal will often lower the tension.

Abrams's pulse method of testing for cardiac insufficiency is to compare the pulse of the patient when lying and sitting. The latter should show normally an increase of from four to six beats.

Vasomotor insufficiency is indicated by a higher tension when lying than when sitting. The following will illustrate the effects of vibratory treatment of this interesting and extremely common condition:

CASE I.—Mr. M. came under observation January 17, 1913, suffering from exhaustion, depression, and nervousness.

His pulse was 72 sitting and 78 lying, showing a cardiac insufficiency, and his tension was 142 sitting and 142 lying, showing sluggishness of the vasomotors and splanchnic engorgement. Vibration was applied with the ball vibratode between the second and fifth dorsal vertebræ for five minutes, as previously described, to restore tone to the vasomotor nerves, and for two and a half minutes between the seventh cervical and first dorsal to relieve the cardiac insufficiency, with the following results. It will be noticed that in this case, after the first treatment, both pulse and tension assumed their normal postural relations.

Date 1913	Pulse: Sitting Before	Pulse: Sitting After	Pulse: Lying Before	Pulse: Lying After	Tension: Sitting Before	Tension: Sitting After	Tension: Lying Before	Tension: Lying After
Jan. 17	72	72	78	68	142	136	142	132
Jan. 18	70	—	64	—	130	——	124	——
Jan. 20	84	84	80	76	128	120	120	116
Jan. 24	84	80	76	72	126	120	122	114
Jan. 28	64	72	60	62	126	120	120	116
Feb. 3	—	72	—	70	——	124	——	120
Feb. 5	—	68	—	62	——	124	——	120
Mar. 6	76	—	—	72	——	120	——	112

CASE II.—Mrs. B. came for treatment January 18, 1913. She complained of being "always tired," and not able to exert herself physically or mentally. Her pulse was 68 sitting and 72 lying, and her tension was 138 sitting and 140 lying. Vibration was applied for five minutes in the manner described with the ball vibratode between the second and third, the third and fourth, and the fourth and fifth dorsal vertebræ to tone up the vasomotors, employing moderate pressure and just such a rate of speed of the vibrator as to make it agreeable. Vibration was also applied for two and a half minutes between the seventh cervical and first dorsal vertebræ to relieve the cardiac insufficiency. No record was made of her tension and pulse after treatment, but on her return two days later the pulse showed no disparity and her tension remained reversed.

The following day the pulse showed no disparity, but after treatment there was a difference of two, the tension remaining reduced and in proper ratio.

On her return a week later the pulse showed no disparity, but after treatment a difference of four was noted, since which time it has been keeping its increase on the right side, being higher when the patient is sitting than when lying, the tension also maintaining its proper ratio.

Date 1913	Pulse: Sitting Before	Pulse: Sitting After	Pulse: Lying Before	Pulse: Lying After	Tension: Sitting Before	Tension: Sitting After	Tension: Lying Before	Tension: Lying After
Jan. 18.	68	—	72	—	138 mm.	————	140 mm.	————
Jan. 20.	64	—	64	—	130 mm.	————	128 mm.	————
Jan. 21.	60	62	60	60	130 mm.	124 mm.	126 mm.	120 mm.
Jan. 28.	64	70	64	64	128 mm.	124 mm.	130 mm.	124 mm.
Feb. 3.	64	74	60	60	130 mm.	124 mm.	126 mm.	120 mm.

Date 1913	Pulse Sitting Before	Pulse Sitting After	Pulse Lying Before	Pulse Lying After	Tension Sitting Before	Tension Sitting After	Tension Lying Before	Tension Lying After
Mar. 3.	72	—	64	—	128 mm.	———	120 mm.	———
Mar. 21.	70	—	68	—	132 mm.	———	130 mm.	———
Apr. 29.	64	—	60	—	126 mm.	———	120 mm.	———

Case III.—Mrs. G., age 48, referred to me on January 24, 1913. Complained of being tired. Has a uterine fibroid. The pulse was 96 sitting and 100 lying, the tension 152 mm. sitting and 154 lying, the pulse ratio showing cardiac insufficiency and the tension ratio vasomotor insufficiency. The tension was reduced to 140 mm., but no record was made after treatment at the first visit. Two days later her pulse ratio was again abnormal, and her tension ratio still showed a disparity of 2 mm., being 134 mm. sitting and 136 mm. lying. This was corrected by vibrating between the second and third and the third and fourth, and the fourth and fifth dorsal vertebræ inclusive, for five minutes, resulting in a difference of eight, the pressure being 138 mm. sitting and 130 mm. lying. This illustrates the remarkable results sometimes obtained when restoring the proper relation. The tension when sitting was raised four millimetres and the tension when lying was lowered six millimetres.

From this time on her pulse remained higher sitting than when lying. After two weeks' time the tension gave the same reading both sitting and lying before vibration—112 mm. Vibratory treatment changed the reading to 108 mm. sitting and 106 mm. lying, a reduction of 44 mm. from the commencement of the vibratory treatment. Two subsequent readings showed that the pulse and tension still maintained their normal relations.

Date 1913	Pulse Sitting Before	Pulse Sitting After	Pulse Lying Before	Pulse Lying After	Tension Sitting Before	Tension Sitting After	Tension Lying Before	Tension Lying After
Jan. 22......	96	—	100	——	152	140	154	——
Jan. 24......	84	84	90	80	134	138	136	130
Jan. 31......	92	84	84	80	118	112	114	108
Feb. 3......	88	—	82	——	116	——	114	——
Feb. 5......	80	—	78	——	114	——	110	——
Feb. 7......	84	78	82	74	112	108	112	106
Feb. 10......	80	78	78	76	112	108	108	106
Feb. 17......	72	72	68	68	130	124	128	120
July 7......	84	78	——	——	124	120	——	——

Another class of cases is characterized by intermittent pulse associated usually with a high tension.

Mrs. W., age 54, came for her first treatment January 21, 1913, with marked intermittency of pulse—80 sitting and 72 lying. Tension 154 mm. sitting and 148 mm. when lying.

She was vibrated with the ball vibratode between the second and third, and the third and fourth dorsal vertebræ for five minutes for the purpose of lowering her blood-pressure, and between the seventh cervical and first dorsal vertebræ to tone up the heart and lessen the intermittency. The writer has observed that in weak or dilated hearts the best results are obtained by more vibration on the left side than on the right. Whether vibration on the left side alone will accomplish the end sought is yet to be determined.

Date 1913	Pulse: Sitting Before	Pulse: Sitting After	Pulse: Lying Before	Pulse: Lying After	Tension: Sitting Before	Tension: Sitting After	Tension: Lying Before	Tension: Lying After
Jan. 21.......	80	—	72	—	154	140	148	
Jan. 23.......	80	—	80	—	138	130	134	
Jan. 25.......	—	72	—	72	—	138	—	134
Jan. 27.......	78	76	80	72	130	130	132	126
Jan. 29.......	76	72	72	66	130	122	126	120
Jan. 31.......	72	76	72	68	130	124	126	122
Feb. 3.......	72	76	72	72	124	124	122	120
Feb. 5.......	72	74	72	68	124	124	120	118
Feb. 7.......	72	78	74	72	120	120	120	112
Feb. 11.......	76	—	72	—	118	—	114	—
Mar. 5.......	72	72	72	66	118	114	112	110
May 13.......	72	72	68	64	120	118	118	114
May 24.......	68	72	70	66	116	114	116	108
May 28.......	76	72	76	68	116	114	112	106

Reference to the above figures will show that in the pulse ratio the difference when lying or sitting tended toward zero, and in two instances the tension showed no difference. At these times the patient reported that she was not feeling so well as at others, and gave good and sufficient reasons for the same change noted. The intermittency was markedly benefited.

In addition to mechanical vibration, all of the above cases had the static wave current applied over the liver by means of a flat metal electrode to restore the functional activity of the great filter and sterilizer of the system. All records, however, were taken before and after the application of mechanical vibration, and before the static treatment.

Sometimes the first treatment will not effect a complete change, but will produce differences in tension and pulse taken with the patient lying and sitting equal to zero. The second or third treatment will show the desired increase in the right direction.

It is well at first to give these patients daily treatments until the desired result is maintained, after which an interval may be allowed. If this interval is too long, or if the patient has suffered from some indiscretion in diet or from overwork, he may show a relapse; but, as a rule, the results are lasting, and the physical effects derived most gratifying to the patient and practitioner.

If the skilled general practitioner will but use vibration in cases to which it is applicable, he will be rewarded by results which cannot be attained by drug therapy.

STATIC ELECTRICITY: ITS PHYSICAL AND PHYSIOLOGICAL EFFECTS AND THERAPEUTIC INDICATIONS

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The term "*static electricity*," applied to the form of electricity under consideration, is induced by means of friction on glass or other non-conducting material, as by rubbing an animal fur or flannel against a revolving glass plate or a stick of sealing-wax. Electricity so produced was called "static" because, when accumulated in a Leyden jar or upon the disks of a static machine or other insulated surface in a dry atmosphere, it did not escape for considerable time. When the outer coating of a Leyden jar is connected by a metallic or other conductor with the inner coating, or when the end of the rod connected with the inner coating is approximated near enough by a grounded connection, or capacity, however, a discharge in the form of a spark will pass, manifesting to a remarkable degree a kinetic quality; and in this respect the name is a misnomer. The current is *static* only when a charge is restrained upon the surface of an insulated capacity in a dry atmosphere.

This form of electricity during the process of generation by a modern Holtz, Toepler-Holtz, or Wimshurst machine manifests most actively a kinetic quality, filling the air of the room with its discharge, and escaping by sparks to a body or person approaching the insulated body in a state of charge. No current from other sources of the same ampèrage and voltage will so affect conditions or produce manifestations of electrical stress similar to those of the current from a static machine. To be more specific, a current generated by passing a direct current through a Ruhmkorff coil, capable of discharging a twenty-inch spark between the terminals, is barely appreciated by those in the room except by the noise of the discharge; whereas, a small static machine, capable of producing a spark of not more than

four or five inches, causes the hairs of an individual in the vicinity of a person upon the insulated platform to stand up, accompanied by a sensation as of a draught of air blowing upon him. That quality of static electricity would make the name more properly "*kinetic*" than "*static.*" The term "*static electricity*" as applied to the electricity of the clouds, and as generated by friction or induction by a machine of the static type, has, through custom, become distinctive in electrical nomenclature. The characteristics, however, for which it is used in therapeutics are the active kinetic properties to which must be attributed its remarkable mechanical effects.

The types of machines that have been used during the various stages of development of electrical science have varied from the ancient spheres made of amber to the revolving glass disks, single or multiple, as employed by Franklin and others in the friction machines, and to the later types of the Holtz, Toepler Holtz, and Wimshurst machines, so called after the names of their inventors.

The distinctive feature of the Holtz machine, which makes it especially valuable for most static therapeutic work, is that currents of far greater energy are generated by induction. The stationary plates are separated with the sectors arranged upon opposite sides in such a manner that the internal resistance of the machine is sufficient to make possible the discharge at regular periods of long sparks between the terminal balls at the spark gap; whereas, the Toepler-Holtz, also an induction machine, is generally constructed with circular stationary glass disks, upon which the two charged fields are oppositely placed, and across which some current passes even under the most favorable conditions, interfering with the production of long rhythmical spark discharges when the wave current is administered. This condition of things is not unfavorable to the administration of the X-ray or high-frequency current, which do not require so high internal resistance.

The Wimshurst machine is a self-exciting combined friction and induction machine, in which each pair of parallel disks revolve in opposite directions.

The Holtz and Toepler-Holtz machines are dependent upon some other source, as a Wimshurst, for an exciter, for the production of an initial charge, after which the current is produced by induction. The revolution of the disks near parallel charged surfaces produces

the current indefinitely, and will not lose the charge for several hours under dry atmospheric conditions.

In this country static machines are put in relatively air-tight cases, in order that the degree of dryness of the air under which the currents are excited may be controlled by placing materials inside which will absorb the moisture, such as quicklime or sulphuric acid. If these machines are properly cared for, the static charge will be constant in the Holtz machine for from twelve to twenty-four, or even thirty-six, hours. In order to effect this, the opposite poles must be kept separated when the machine is at rest.

The medical uses of static electricity have held varying degrees of credence in the minds of medical men at different periods. In the earlier days it was more often recognized and used medically by scientists other than physicians. Abbot Nollet, Cavallo, Benjamin Franklin, John Wesley, and other scientific observers, studying this form of electricity, made therapeutic uses of static sparks. Benjamin Franklin did much by his investigations to popularize the medical use of electricity, and is reported to have wrought remarkable cures with his static machines. The medical use of static electricity has for this reason become known as "Franklinism," and is frequently so designated.

Manifestations of electricity as generated by the crude one-pole apparatus of Franklin, and as studied by him in his classic kite experiment when electricity was drawn from the clouds over the string of his kite, probably led Franklin to adopt the one-polarity theory of electricity which was later contradicted by scientific investigators, to be again adopted by Thompson, Ramsey, and others. This theory, however, probably will not stand the test of time when compared with electricity as exhibited in a modern Holtz machine. In reply to a recent inquiry by the writer, no less an authority than Professor Samuel Sheldon, Ph.D., writes: "Assume a circuit carrying an electric current to be partly metallic and partly gaseous. There is ample evidence of a progression of positively charged carriers in one direction in the gas, and of negatively charged carriers in the opposite direction in the gas," and then concludes: "To my knowledge there is no evidence of the former in metals, but there is of the latter." Statements from so high an authority are verified in the observation of others in the phenomena of the

static machine. It is an open question whether Thompson and Ramsey studied the phenomena of electricity from the point of view of static manifestations as did Dr. Sheldon and others. The different therapeutic effects derived from the employment of opposite polarities in the treatment of various inflammatory and other conditions further disprove the one-polarity or one-electricity theory.

Physical Properties.—I. Attraction and repulsion have been demonstrated in all text-books on electricity. That unlikes attract and likes repel—the two features, centripetal and centrifugal are kinetic properties always in evidence. We emphasize this fact, for it is evidently due to these qualities that static electricity possesses its distinctive therapeutic properties. When bodies are in a state of electrical charge the electricity surrounds them on all sides. Static currents, even small ones, as excited by friction of the feet upon the carpet, are capable of discharging sparks easily from one-eighth to one-fourth of an inch in length, representing a considerable voltage. Static electricity is peculiar in the relatively high voltage or potential and small ampèrage in which it may exist—a striking characteristic of this form of electricity.

Another property of static electricity is its peculiar quality of diffusion or conduction whereby the current passes readily through the air and other materials which are not conductors of other currents, such as wood or fibre, and even over a surface of plain glass which is hydroscopic. It is to these properties that the remarkable kinetic qualities of the static modalities are largely attributable, and to which they owe their distinctive value in therapeutics. The same law of electrical conduction obtains as with other high potential currents, whereby the current, when passed through a conducting medium, is instantly dissipated with each discharge, the recharge depending upon the constancy of the source.

When an alternating current of very high potential or a condenser discharge is conducted to a metallic horseshoe arc or circuit, it will pass by a spark across an air gap of a width commensurate with the voltage of the current instead of passing around over the conductor. This property of high potential discharges demonstrates the certainty of its passage to and fro through the conducting tissues of the human body. It has been claimed by some medical writers, not authorities, however, in electro-physics, that static electricity does

not pass through the tissues of the body, but only over the surface. Under the latter hypothesis, if electrodes are placed upon opposite sides of the human body, the static current would pass over the skin of the body and not through it; or, if one electrode be placed upon the body and the patient insulated, the current will be discharged over the skin to the electrode from all points to the metallic electrode, or by a spark discharge. When a discharge, however, passes across an air gap, instead of making a metallic circuit, it is preposterous to presume that a current will pass over the skin, which is a poor conductor to surround the body. It will certainly be discharged through the body, which is practically a normal salt solution. Therefore, every principle of the laws of electricity insures the passage of the static current by the shortest route to every part of the surface, both to surround it and to be discharged when the person is insulated. This explanation would be unnecessary if statements had not been made to the contrary by those who are authorities in other matters.

To the distinctive physical properties just described must be attributed the therapeutic effects characteristic of the static current. The ampèrage produced by static machines is relatively so very small and the potential relatively so very great that, while the current is as directional a current as the constant (galvanic) current, the electrolytic effect is practically *nil*, and is therefore a negligible quantity, not to be considered when employing the static current. It does, however, possess the same properties as the constant current in effecting *independent muscular contraction*. In other words, it is capable of producing cell contraction, independent of a nerve impulse, and, furthermore, the high voltage of the current causes it to pass readily from the surface of an electrode through the resistant skin and thus affect the muscular cells *en masse*, regardless of the nerve supply, thereby producing muscular contraction independent of the nervous system. With the static modalities, therefore, it is unnecessary to apply the current to motor points, but locally to the parts to be affected, the contraction resulting from a direct action of the current upon the muscle cells, producing, locally, immediate contraction of the muscular tissues beneath the electrode, and reflexly throughout the extent of a muscle.

It is the mechanical effect of the static current, inducing as it

does responses in the muscle, and reflexly in the neuromuscular mechanism, that gives the static current its definite place in therapeutics.

Certain well-defined laws which govern tissue responses to electrical stimuli must be recognized:

I. Nerve and muscular tissue respond to less than six hundred interruptions in, or impulses of, an electrical current per minute, with periods of contraction alternating with intervals of release.

II. When the interruptions are more than six hundred per minute, or less than ten thousand per second, the contractions become tonic muscular spasms, which persist until the current is interrupted.

III. All muscular contraction or muscular response ceases when the rate of interruption exceeds ten thousand per second. This rate marks the point at which *high frequency* properly begins as applied to alternating currents, or *high periodicity* as applied to directional currents.

When hydrogen had been resolved into negative electrons as demonstrated by Sylvanus Thompson, and the experiment had been accepted by other observers, it seems to have been demonstrated that electricity exists in fact as substance; or, as Sir Oliver Lodge puts it, "the thing of which matter is made"; or, in the words of Dr. Sheldon, electricity "is a material which, when in motion, exhibits magnetic, chemical, and thermal effects, and when at rest or in motion exerts a force on other electricity." Under these circumstances, another mechanical effect of electricity must be recognized besides the induction of muscular and tissue contraction,—the mechanical effect (insensible) due to the passage of myriads of substantial electrons through the tissues. Such passage of great numbers of these bodies, though infinitesimal in size, to and fro through the tissues, explains the remarkable clinical effects of accelerated general metabolism as observed by those familiar with the employment of high potential electrical currents in therapeutics.

For the better understanding of the therapeutic effects, a knowledge of the special methods of application which are generally designated as *modalities* is important.

The five modalities of most value are: (1) the static wave current, (2) the static spark, (3) the static brush discharge, (4) the static induced current, and (5) the vacuum tube wave current. These

modalities are peculiarly adapted to the treatment of definite classes of particular conditions.

The static wave current was first published by Professor Wm. J. Morton, after its therapeutic value was recognized in his offices by the writer.[1] It probably covers the largest field of indication of any of the static modalities, and is also probably the most valuable of all electrical modalities. The distinctive features in the employment of this current are as follows: The patient is insulated, a suitably retained electrode adapted to the condition to be treated is attached by a plain wire or other rheophore to the positive side of the machine, the negative pole is grounded, and a spark of regulated length is allowed to discharge at the spark-gap between the terminal balls of the discharging rods. The regulation of the dosage of this current will depend upon two factors: (1) the size of the terminal balls, and (2) the length of the spark discharging between the terminals, regardless of the capacity of the machine.

The size of the terminal balls determines the current condensation, or the volume of current held back before a discharge takes place. The larger the ball the greater the charge condensed or accumulated.

The length of the spark-gap between terminals of a given size determines the volume of charge which the patient will take before, and also the extent of the local effect at, the instant of discharge if the person is seated or lying upon the static chair placed on the insulated platform. The amount of current accumulated and the effect produced are therefore in proportion to the ratio of these two factors.

The patient receives the charge passively, without appreciable effect other than that manifested by the standing up of the hair upon his body or of loose threads on the surface of his clothing. The instant a discharge takes place and the current escapes, the electricity surrounding the body passes in straight lines to the electrode placed upon the surface or within one of the cavities of the patient's body. Greater condensation, and consequently greater tissue response, takes place immediately beneath the electrode, which, other things being equal, also varies in degree and extent with the length

[1] "Static Electricity and Uses of the X-ray," Wm. Benham Snow, page 54.

of the spark-gap. In this way the discharge, when the spark-gap is long and a great charge has been condensing upon the surface, escapes with speed and force, the current condensing as it approaches or focuses to the glass vacuum or metallic electrode. At the instant of discharge the tissues contract in the immediate field of the electrode. So, if applied to the spinal cord through a narrow strip of soft metal applied over the spinous processes, the energies of the current are expended upon the substance of the spinal cord. Bone offers little or no resistance to such high potential condenser discharges, the current passing directly through the cord to the spinal electrode. In order to produce the utmost degree of local physiological effect, the electrode, wherever applied, should be relatively small, the spark-gap long, and the intervals between the charge and discharge so regulated that the periods of contraction shall approximately equal the periods of release. A rate of from 120 to 300 per minute, which may be controlled by regulating the speed of the machine to the length and rate of discharge, will give the best results with least discomfort to the patient.

The indications for the use of the wave current in therapeutics are (1) to soften indurated and infiltrated tissue by the induction of alternate tissue contraction and release; (2) by the same effect to overcome muscular spasm; and (3) for the effects upon general metabolism.

By this method, as first demonstrated by the writer,[3] and now recognized by all familiar with the subject, it is possible to relieve local infiltration from even relatively large areas, thereby producing tissue drainage through the lymphatic channels and inducing active circulation in the tissue, the seat of local *stasis*. This is effected with facility and with no unfavorable or untoward result when the tissues are not infected. The pain associated with the induced contraction of the inflamed or infiltrated tissue is easily made endurable to the patient by gradually regulating the spark-gap to the point of toleration. In other words, if too great pain follows the induced contraction of the engorged tissues beneath the electrode during the process of treatment, the pain may be lessened by shortening the

[3] "Static Electricity and Uses of the X-ray," Snow, page 76.

spark-gap while at the same time slowing the speed of the machine to regulate the rate of discharge. As the pain diminishes with the softening or relaxation of the tissues, the spark-gap should be gradually lengthened until the contractions, however marked, cause no pain, or to the end of the usual twenty-minute limit of the time of application. Under ordinary conditions, and when placed over normal tissues, except upon the scalp or forehead, the muscular responses to the wave current will cause no painful effects whatever. It will be readily appreciated, therefore, that the production of pain by the current becomes diagnostic, thereby localizing areas of infiltration or muscular contraction or both; because, when the current is applied to areas of local muscular contraction or infiltration, pain is invariably produced.

The static spark is the oldest of the static modalities used in therapeutics. It was employed, as previously stated, by Abbot Nollet, Benjamin Franklin, and others, who reported that they had cured various inflammatory troubles. The employment was then empiric, and used chiefly by laymen, thus obtaining little credence in the minds of the medical profession. Later demonstrations have proven its use practical and free from empiricism.

The mode of administering the indirect static spark, and the most practical method of administering sparks, is as follows: With the patient seated or standing upon the insulated platform, a metal rod or " shepherd's crook " connects the platform with the positive side of the machine, the negative side being grounded to a water-pipe or other metallic conductor to moist earth. The sparks are then administered with the sparking ball, which is connected with another grounding chain, the operator holding the handle of the sparking ball in his hand with the chain, the hook or snap of which is placed in the eye on the side of the electrode, taking care to prevent it from swinging against the platform, or the patient upon the insulated platform. The patient's feet should be at least far enough away from the end of the connecting rod or metal plate on the platform to prevent a spark passing to him during the application. All is then ready for the administration and the machine may be started. The sparks may then be made to pass directly between the ball and the infiltrated tissue, the site of a non-infected inflammatory affection, or a muscular spasm. Some time ago the writer introduced

a method by which it became possible to localize sparks at exactly the point desired by means of a spark director. This is held so that the metallic terminal comes in contact with the spot where the spark should be delivered, and then the spark is applied to the metal ring near the patient's end of the director.[3] By this means it is possible to direct the effect of the spark discharge between toes, or to any hollow or depression, or into a cavity of the body; whereas a spark would otherwise pass from the sparking ball to the nearest convex surface. This also obviates the interference of fuzzy particles upon the clothing of the patient, which would otherwise direct it away from the site to be treated.

The indications for static sparks in therapeutics are as follows: For the localized relief or softening of small, deep-seated areas of infiltration, particularly in and about the joints, as about the malleoli; in cases following ankle sprains, in which painful areas often persist for months, and cause more or less constant annoyance to the sufferer. In such cases the administration of a few sparks around and about the ankle will usually give instant and complete relief. In synovitis and rheumatoid arthritis nothing will give the immediate relief that static sparks will, painful though the treatment may be. The spark is also the most prompt and effective method of relieving local muscular tension, as complicating neuritis and synovitis.

The length of spark during administration should be regulated by the depth of tissue to be affected,—one-half inch or less in length to the fingers and hands; one to two inches to the forearm; two to three inches to the arm and shoulder, and four inches about the thigh, hips, and back. The length of the spark delivered is usually regulated by controlling the speed of the machine. Sparks should always be applied to a timid patient with a spark director, because the sight of sparks leaping from the body is liable to cause needless alarm. It should always be demonstrated that the pain produced will give relief, as the patient always finds that he can move the arm or part treated more freely after a few sparks, and this relief will encourage him to tolerate them willingly. The cessation of pain is not due to benumbing of the tissues, but to relief from pressure and muscular tension, as is readily demonstrated by the final out-

[3] "Currents of High Potential of High and Other Frequencies," Snow, page 45.

come. The notion that static modalities give but temporary relief arises from failure to give regular treatments frequently until relief is permanent. The time required to effect permanent relief depends upon the chronicity of the case, early cases being promptly cured; while the exudations, and resulting adhesions occurring in neglected cases, require longer courses of treatment. In all except very chronic cases success is the rule when the lesion is accessible.

The static brush discharge has long been known, but was not appreciated until its therapeutic value had been fully pointed out by the writer.* It is administered by the following arrangement: The patient, sitting or standing upon the insulated platform, is connected by a metallic connection, the so-called shepherd's crook, with the negative side of the machine, with the rod in his hands. (Note the distinctive fact that the patient is connected with the negative side of the machine.) The balls of the discharging rods are widely separated and the positive side of the machine is grounded, when the operator, with the special electrode also grounded, applies the effluve or brush discharge to the surface requiring local treatment by rapidly moving the electrode to and fro over the surface at a distance; this produces a distinctive sound, as though coarse sand was being projected against the part.

The distinctive quality of this mode of application is the peculiar effect derived by completion of the circuit through an electrode of resistant material. The electrodes first designed by the writer were made of wood, soft or hard and of even texture, as white wood or maple. It was discovered that when these sticks became thoroughly seasoned they were no longer practical, because they became too resistant, and did not permit enough current to pass through to produce an effective discharge. This led at first to the purchase of new sticks of unseasoned wood, and later to the practice of frequently moistening the wooden sticks on the exterior with a damp towel held in the hand of the operator. Some operators keep the sticks in a damp place when not in use, and Dr. Titus dampens them with a ten per cent. solution of glycerine, which does not dry off from the surface as rapidly as water. Later an electrode was intro-

* "Static Electricity and Uses of the X-ray," First Ed., Snow, page 36, and "High Potential Currents of High and Other Frequencies," page 43.

duced which consisted of a glass tube filled with glycerine and provided with a wooden terminal. This electrode worked well until the wood became saturated with glycerine or when it was too dry. A happy medium of saturation of the ball terminal is essential to the perfect action of this electrode. A more recent type of electrode has been designed by an engineer at the suggestion of Dr. de Kraft. It is made of fibre with a metallic terminal, filled with some material which gives an even resistance, and from which it is possible to administer the discharge in a practical manner without sparking. In the past efforts have been made to produce an electrode which would give an even discharge of considerable volume, and cause a subjective sensation as of hot sand when discharged against the skin of the patient, the sound also appearing to the operator as if sand were being thrown against the part. Such an electrode should be provided with both metallic point and ball terminals, the former for administering the blue pencil discharge described by Dr. de Kraft.

The physiological effects of this discharge are two-fold: (1) the stimulation of peripheral tissues, thereby producing an active hyperæmia to considerable depth, and (2) the relief of exudation in superficial tissues, either from *inflammatory stasis or œdema.* With a properly-operated discharge it is possible to remove the infiltration, as, for instance, from the œdematous tissues surrounding a varicose ulcer, to a depth of five-eighths to three-fourths of an inch, thereby softening the parts and promoting the return of circulation.

The static brush-discharge employed in the manner described is one of the most practical means for the treatment of superficial congestion, as associated with *sprains and bruises,* as well as for promoting prompt absorption of ecchymoses. There is probably no better treatment for varicose ulcers, either alone or combined with radiant light and heat. The softening of the tissues surrounding the ulcer and stimulation of the circulation of blood to it, with the added local antiseptic effect of ultra-violet discharges to its surfaces, promote rapid healing.

In phlebitis following the prolonged application of radiant light this modality promptly relieves the infiltration in the walls of the veins and the surrounding cellular tissues, and as a consequence restores the circulation and cures the condition in a few days or a

few weeks, according to the stage of the trouble. In addition to numerous other cases, the writer has in this manner cured among others two cases of phlebitis in the upper third of the great saphenous vein, one of more than one month's duration in a large man weighing over 250 pounds.

The method is also remarkably effective in the treatment of chronic dry eczema, in cases following X-ray treatment of lupus vulgaris and lupus erythematosus, and in all cases of superficial non-infected inflammation, whether arising from injury or otherwise. It is invaluable in the treatment of every superficial condition to which it is adapted.

The static induced current, the first of the static currents published by Dr. Wm. J. Morton, is a two-pole current,—*i.e.,* operated with two electrodes in contradistinction to the one-pole wave current,—and was the first of the high-frequency currents discovered. In the present consideration of high-frequency currents, however, it does not attain to a rate of oscillation of more than ten thousand per second, at which tissue responses cease, this marking the rate of high frequency in the modern use of the term. It was after Dr. Morton's discovery of this current that the present advance in our understanding of high-frequency currents began, and it will always be recognized as the first of the high-frequency currents.

The uses of the static induced current are not so varied as of the static wave current, because the effects are purely mechanical, and localized to the tissues immediately beneath the two electrodes, the patient not being in a state of charge during the administration. The principal use of this current is in the simultaneous treatment of two large joints, in the treatment of obesity, and to exercise affected muscles in poliomyelitis.

Obesity is treated in the following manner by the writer: A large electrode of soft metal, approximately twenty-two inches long by twelve to fourteen inches wide, extending from the sacrum to the neck and across the back, is moistened and placed next to the skin, then connected by a wire to the binding post corresponding to the outer side of one of the Leyden jars. Several smaller electrodes are also placed in position upon the abdomen, shoulders, thighs, and legs, all of which are connected by wires to one common cord or wire which is attached to the binding post of the other Leyden jar.

The speed of the machine is regulated so as to make approximately one hundred and twenty discharges per minute, and the spark-gap to a length that will produce positive but not painful contractions. With each discharge the muscles are thrown into responsive activity and, when properly regulated, without pain. If this be kept up for more than ten or fifteen minutes with a person who has not been accustomed to exercise, the amount of effete matter thrown into the circulation through the lymphatic channels is often sufficient to produce a violent toxæmia. If, however, for a month or six weeks, the administration is made for ten minutes daily for the first week, and increased to fifteen minutes the next week, and five minutes added after each five days, the metabolism of the patient will eliminate the waste products of exercise even when the current is continued for a half-hour or more. It will be readily seen that this method is practicable from the viewpoint of exercise and resulting tissue combustion, and that patients under such exercise are certain to become physically stronger and more vigorous. The muscles develop, and the fats are correspondingly diminished. Providing the diet is so regulated that a minimum of fats and carbohydrates are consumed, the weight will diminish. The method simulates that of Bergonié, who employs the induced (faradic) current, with multiple electrodes connected in such a way as to produce rhythmical contractions at the same rate of one hundred and twenty per minute.

The static induced current can also be used to advantage in the synchronous treatment of two large knee-joints when with the wave current it would require twice as long to produce the same decided local mechanical effect required. The constitutional effects of the static wave current, however, are often desirable. It may also be used in the same manner as for obesity to exercise atrophied muscles, using multiple electrodes, in cases of poliomyelitis.

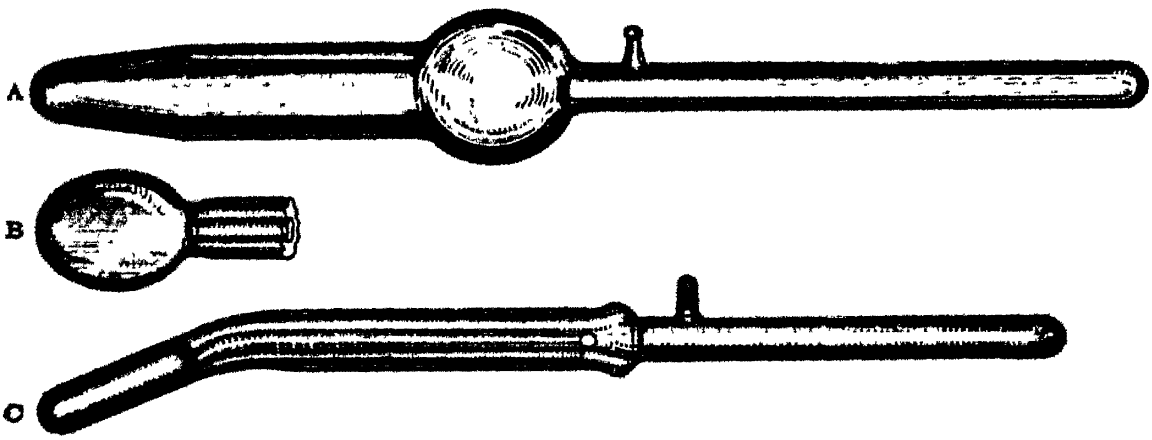
The vacuum tube wave current, first described by the writer,* produces the mechanical effects of the static wave current, but with less intensity and an added local effect from the vacuum tube discharges at the surface of the glass. For the sake of this latter effect it is sometimes used with benefit in the treatment of inflammations in the various cavities of the body in which superficial local infection of the mucous surface may play a part. This current is ad-

* "Static Electricity and Uses of the X-ray," pages 40 and 41.

ministered with variously-shaped electrodes adapted to the different cavities or surfaces of the body, and may be used instead of the static wave current. It is especially adapted to the treatment of mucous cavities, and has been found invaluable in the local treatment of recent hemorrhoids and of fissure in ano, employing the electrodes shown in Fig. 1, *A* and *B*.

One form of vacuum electrode (Fig. 1, *C*) has proven particularly beneficial in inflammatory affections of the mouth. It is so insulated that the current may be applied to various parts without producing the very disagreeable metallic effect otherwise experienced on coming into contact with the teeth. The writer has found it valuable in the treatment of facial neuritis involving the inferior dental nerve,

FIG. 1.



Various types of vacuum electrodes. *A* and *B* for use in the rectum. *C*, for the mouth.

placing it over the nerve where it enters the bone, and holding it firmly in position during the treatment of twenty minutes' duration.

The systematic employment of these five modalities will meet the requirements in most cases of non-infected inflammation. In this class of inflammatory cases without infection, which would otherwise be set free by the mechanical action, the static current safely and quickly relieves local infiltration or stasis and facilitates prompt recovery.

The characteristic mechanical effects of the static modalities upon the non-infected cases to which they are adapted the writer has found to accomplish results impossible with other means. It will relieve many conditions coming under the following classification: contusions, sprains, neuritis, synovitis, and local conditions in rheuma-

toid arthritis, prostatitis, dysmenorrhœa, subinvolution, torticollis, lumbago, varicose ulcers and phlebitis, as well as conditions referable to the glandular organs of the body, including exophthalmic goitre, prostatitis, congestion and cirrhosis of the liver, enlarged malarial spleen, the pancreas in diabetes, intestinal stasis associated with constipation, and congestion of the kidney in nephritis. The indications for the use of the static wave current are remarkable, as will be universally recognized when its action and effects are generally understood.

The writer's personal experience comprises successful results in the treatment of more than four hundred cases of neuritis, including intrapelvic, sciatic, brachial, facial, intercostal, and practically every region of the body. The acute cases usually yield in from four days to ten weeks. Upward of seventy early cases of *sciatica* have been completely cured, every one within ten days. The results have not been uniformly duplicated by any other method.

Favorable results have been obtained in the treatment of pelvic congestions by the use of a cylindrical metal electrode placed in position in the rectum over the septum against the uterus. These include cases of *subinvolution, dysmenorrhœa, and ovaritis.*

In prostatitis the results secured when the same electrode is applied on the rectal side of the gland are remarkable. It is a great boon to these sufferers, favorable and relatively uniform results being obtained in such cases, effecting, in the writer's hands, permanent relief in more than ninety per cent. of the uterine and prostatic cases mentioned.

In synovitis the improvement of function in the joint following the removal of infiltration, as in other cases, is effective in a majority of early cases. To secure the most prompt and favorable results it must be employed with all due attention to technic,—*i.e.*, with a thoroughness that completely removes the infiltration associated with stasis from all parts of the joint.

In Goldthwaite's disease, or sacro-iliac luxations, the first indication is to relieve all the muscular tension or contraction affecting the muscles involved; then to maintain the relaxation secured by daily treatment until luxation no longer recurs. To accomplish this a large, flat, soft metal electrode should be adjusted evenly over the glutei muscles and the lower end of the quadratus lumborum, employing the wave current, with gradual lengthening of the spark-

gap, as the muscles relax up to eight to twelve inches; thereafter applying another electrode over the adductors of the thigh, these being uniformly in a state of spasm in such cases on account of the irritation of the lumbosacral cord where it crosses the synchondrosis. It may be necessary to place an additional electrode in the rectum to relieve a neuritis of the nerves at the brim of the pelvis. This should include institution from the outset of systematic exercise, the patient lying first on the back, and then resting on the heels and shoulders, raising and lowering the body to and from the opisthotonos position. The muscles thus exercised bring the parts into, and fix them in, proper position. After the first treatment, manipulation of the parts, with the patient lying prone after the muscles are relaxed by the current, usually effects replacement. This cannot be readily accomplished while the muscles remain tense. But, under proper management, and in an early case, it rarely requires more than two weeks to effect a complete cure, and it is often accomplished in less time. During the course of treatment the patient is allowed to walk about in moderation.

Rheumatoid arthritis, conceded to be one of the most intractable of the arthroses, is controlled and clinically cured if the patient can be induced to observe a strict vegetarian diet, combined with the daily use in the first days of high colonic flushings and local treatment of the joints by static modalities until all inflammatory symptoms subside. If local destructive changes have not taken place, the general result in the treatment of these cases is most encouraging. The success uniformly attained by the writer in such cases fully justifies this prognosis.

A few difficult therapeutic problems have been chosen as demonstrating the great value of the static current, which, by many unfamiliar with the methods, is deemed to be of no practical value. If the general principles of employment in accord with indications given in the description of the modalities be observed, in the conditions to which it is adapted, results can be duplicated with a uniformity that is certain shortly to awaken an ever-widening interest in these neglected modalities. The writer is convinced that no therapeutic measures will give greater satisfaction to the medical man who informs himself as to their method of employment for the treatment of defective metabolism, the removal of infiltration, and the relief of local muscular spasm in conditions in which no infection is present.

NEWER METHODS IN THE TREATMENT OF NEURITIS *

DISSECTIONS BY DR. NATHANIEL GINSBURG, OF THE UNIVERSITY OF PENNSYLVANIA, AND DRAWINGS BY EDW. F. FABER, OF THE UNIVERSITY OF PENNSYLVANIA

BY A. B. HIRSH, M.D.
Philadelphia

RECENT advances in the diagnosis and treatment of some forms of neuritis, once obscure in origin but whose causative factors are now as a rule demonstrable, promise much relief, and even cure, of that seemingly intractable affection. The unwelcome sight of decrepit invalids, wandering unhelped from doctors' offices and hospitals, finally to end in the clutches of irregulars or even worse, to the great discredit of our calling, will, let us trust, now become a thing of the past.

ORIGINATING FACTORS

Neuritis may exist because of so many conditions that these may well be summarized and, by way of exclusion, the varieties less frequently seen first described. They include inflammatory or neoplastic changes in the brain or spinal cord and tumors external to the spinal canal, joint diseases, excessive callus after periostitis or fracture, faulty position of fragments after fracture, acute and chronic dislocations. Neuritis may result from such *systemic* states as malaria, diabetes mellitus (when bilateral), syphilis, influenza, or as the sequel of typhoid and other continued fevers; more generally, from intestinal toxæmia.[1] It may depend on poisoning by such extraneous substances as alcohol, or lead, or arsenic. Most cases of neuritis, however, will be found to result from distinct trauma,

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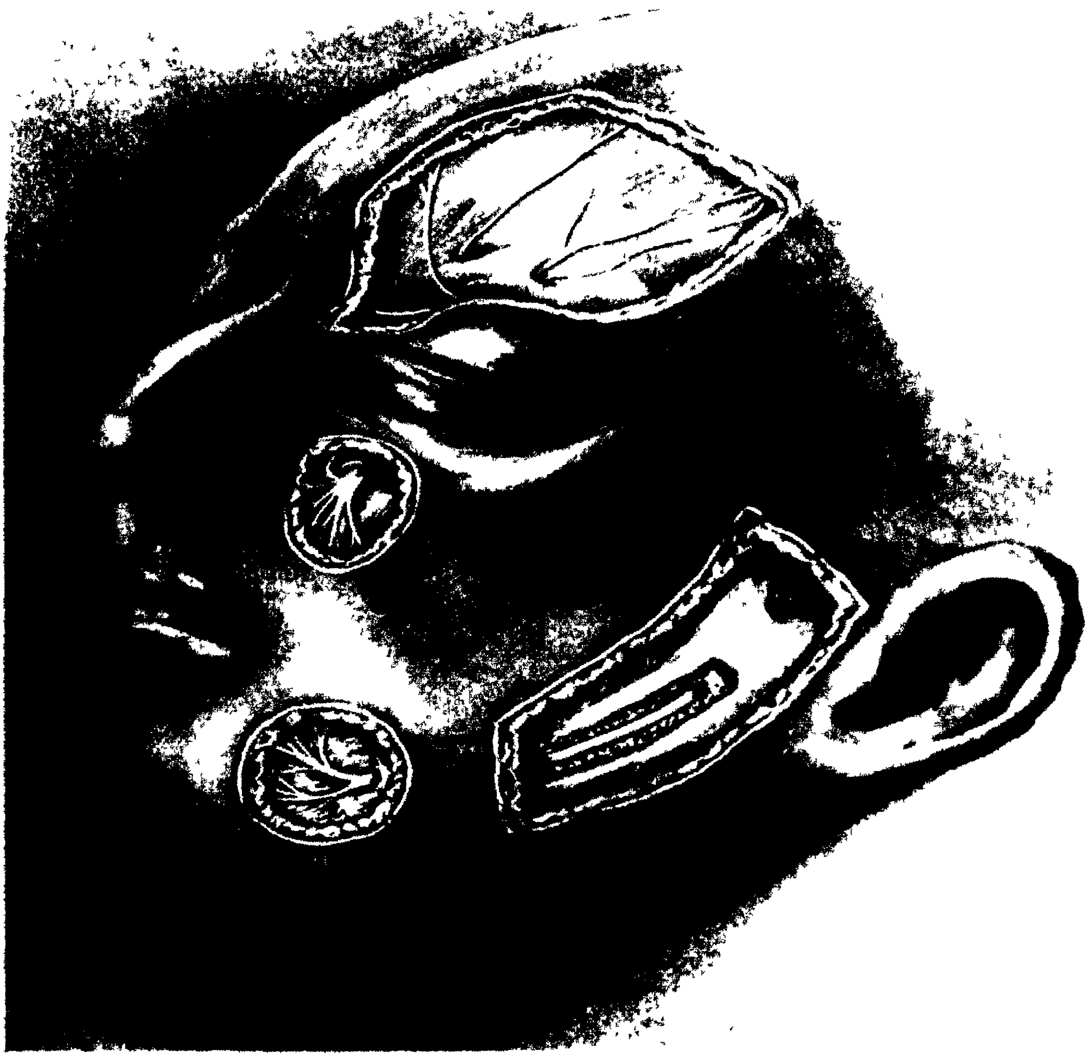
* Read before the New England Society of Physical Therapy at Boston, April 11, 1913.

[1] Graeme M. Hammond: "Neuritis and its Relation to Intestinal Putrefactive Processes," N. Y. Post-Graduate Medical School and Hospital, Contributions, 1908, pp. 20–26. C. E. Skinner: "Arthritis Deformans Treated by Ordinary Methods," *Amer. Jour. Med. Sci.*, 1910, cxl, p. 684 *et seq.* Carl von Noorden: "Intoxication Proceeding from the Intestine, especially Polyneuritis," *Jour. Amer. Med. Assn.*, Jan. 11, 1913, pp. 101–104.

Fig. 1

The facial nerve is here seen emerging between the mastoid process of the temporal bone and the ramus of the inferior maxilla. Its branch distribution affords a guide for the correct application of the electrodes. The lower half of the pinna of the ear and the mastoid attachment of the sternocleidomastoid muscle have been removed, thus exposing the external auditory meatus, and the parotid gland has been sectioned all to show the continuity of the facial nerve.

FIG. 2



The external branches of the trifacial nerve are here given to show sites for application of electrodes for removal of perineural adhesions. Note the anomalous division of the supra-orbital nerve, two branches having separate apertures instead of the usual single supra-orbital foramen. The infra-orbital nerve has its customary multiple division. Enough of the inferior maxilla is removed to show the entrance into the dental foramen of the inferior dental nerve. It is within the mouth, over this dental foramen, that the glass vacuum electrode is applied to remove the neoplastic adhesions often found here.

with, perhaps, exposure to atmospheric changes as an exciting cause. Sometimes history of the combination of these factors may be elicited, but careful differentiation is always requisite for success in treatment.

As the word indicates, we deal with an inflammatory process about the nerve and within its sheath, with or without like inflammation of the tissues contiguous to the sheath. (All observers have witnessed, at autopsy or on the anatomic table, the presence of such adhesions, varying from lacework to ribbons, between the nerve and its sheath.)

The old-time nerve-stretching, where, after free and extensive incision of the overlying structures (say, of the sciatic), the patient lying prone, the surgeon would suspend the nerve trunk upon his finger or the handle of his scalpel, the limb thereby raised from the table, was an early effort to free the parts from this organized lymph. This antiquated method is mentioned, of course, simply to condemn it, although the general profession has not as yet realized the fact of its passing. Only within the past month, indeed, have several *confrères* attached to one of the great hospitals in an Eastern medical centre read formal papers before a medical assemblage in which case histories were cited and this obsolete operation praised as ideal for the affection treated. It was simply an unconscious admission of lack of information as to more effective, non-operative ways of curing this form of neuritis.

Compression of nerve tissue, therefore, and pain in varying degree, often with loss of function, are the sequelæ observed in the patient, and it is chiefly for these symptoms that he consults us.

The nerves *exposed to trauma* are naturally those found by experience to be most frequently affected. They are the superficial branches of the facial and trifacial, the brachial plexus and its branches,—more especially the suprascapular, the circumflex, and the musculospiral,—the intercostals, the crural and, perhaps most frequent of all, the sciatic. (Figs. 1 to 8.)

When neuritis is bilateral, especially when both sciatics are involved, one of at least three conditions should be searched for: (1) Careful urinalysis, having glycosuria in mind, is indicated. (2) If the patient is a woman, examine for a subinvoluted or otherwise enlarged uterus that is pressing directly upon the nerve trunk

or causing reflected pain.[2] (3) If a man, the prostate will probably be found hypertrophied, the double-sided pain, etc., following direct pressure or being reflected through the pudic nerve.[3] Then, too, the possibility should be borne in mind that localized inflammatory deposits may coexist with either of these states, this complication having been treated by the writer in at least one case of each of the last two varieties.

There are two other sites where a localized neuritis should suggest prostatic or uterine hypertrophy as the cause. One of these is where, by reflex action, the pyriformis muscle is in spasm, and presses on the sciatic nerve where the latter emerges from the foramen. (Fig. 7.) The other is where neuralgic pains are more or less continuous about one of the inguinal canals or external rings, due to contracture of near-by muscles from the same source. The ilio-inguinal nerve is here involved. (Fig. 8.) Bearing this fact in mind, treatment must, of course, be directed to the gland or organ.

INSTRUMENTAL DIAGNOSIS

The very multiplicity of treatments heretofore suggested for neuritis in itself indicates etiologic ignorance. Successful treatment, therefore, calls for exact localization of the inflammatory exudate, and here the pulsatory or wave current from the high-power static machine, the patient being seated upon an insulated stand, becomes a necessity.

As the word "wave" signifies, this continuous current rises and falls, with alternate contractions and relaxations of muscular fibre everywhere. Full details as to this modality will be found in the elaborate article on "Static Currents," by Dr. Wm. Benham Snow, of New York, to be found in this issue of the CLINICS, to which the reader is referred. It is largely due to Dr. Snow, as former associate of Dr. Wm. B. Morton, the father of modern static current therapy, that we have such valuable methods of applying it.

Starting, then, with a spark-gap as short as half an inch, with an inch-wide strip of 22-gauge flexible metal (tin and lead, equal parts) bandaged over the affected region and attached by wire to

[2] Arnold Snow: "Mechanical Vibration," New York, 1912.

[3] W. B. Snow: "Currents of High Potential," New York, 1911.

FIG. 3

Removal of overlying tissues shows the upper trunk of the right brachial plexus and its division, with (above the clavicle) the origin of the suprascapular nerve. It is here that the electrode is frequently applied to remove neoplastic material.

FIG. 4

the positive pole, the negative being grounded, distinct pain is felt where the infiltrate compresses the nerve. The spark-gap may be gradually increased to a bearable length, usually about two inches. The glass vacuum tube electrode, likewise attached to the positive pole and kept moving over the affected parts, is at times a convenient substitute.

Should the sciatic nerve, for example, be involved and no adhesions found externally, its intrapelvic course is to be followed. The usual metal electrode carrying the static wave current is inserted into the anus and carried along the anterior surface of the pyriformis muscle until painful areas are reached. Infrequently the lesion lies upon or above the sacro-iliac joint and then, because of its inaccessibility, an accurate diagnosis, as well as prognosis and treatment, becomes increasingly difficult.

"The pain arising from contraction of tense muscles by the wave current may very often be mistaken for the pain due to a [neuritis] lesion," Snow tells us in suggesting the following means of differentiation; "because, when there is muscular contracture, the intense stimulus will increase the contracture and cause pain until the muscles gradually relax. This relaxation, however, will be effected within the first five or ten minutes, when, if the spark-gap is lengthened, the pain ceases; whereas, during the first administrations over the lesion of neuritis, the pain will persist during the *séance* with the gradual lengthening of the spark-gap during the full twenty minutes of the treatment." [4]

These facts also apply to the diagnosis of crural neuritis.

Diagnosis of brachial neuritis is facilitated by passing the vacuum electrode over the affected region. The points of injury are most frequently found where the suprascapular nerve passes out from beneath the trapezius and through the supraspinatus fossa of the scapula; also, where the musculospiral and circumflex nerves curve from under the teres minor muscle. It is here and over the course of the plexus above the shoulder that the metal strip or the moving vacuum electrode, if we are using the static wave current, will find aching spots. The pectorals, infrascapular, triceps and deltoid muscles will generally be found in spasm and painful on motion. (Figs. 3 and 4.)

By passing the same electrode and current alongside the ver-

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[4] "Currents of High Potential," etc., pp. 193–194.

tebræ, where the posterior nerve-roots emerge from the spinal canal (and sometimes simply by digital pressure or by that of the slowly-moving button vibratode), one can localize the lesion of intercostal neuritis, of herpes zoster, of rheumatic neuritis, or of an occupation neurosis. (Fig. 5.)

IS PROGNOSIS POSSIBLE?

In patients with a clear record of trauma it is the *amount* of this inflammatory deposit and the *time* it has existed that will influence the question of partial or complete relief. If only of short standing, a cure may reasonably be expected within ten days or two weeks of daily treatment. When, however, sufficient time has passed to permit of organization of the exudate, with inclusion of the nerve and interference with nutrition in a region or part, then the use of this increasingly painful member lessens accordingly. We now face a more complex situation. Absorption of the foreign material will depend on its volume, its distribution, and whether its locality is within reach of the active electrode. It is only when in some inaccessible situation,—a cavity, for example,—that the prospect of removal becomes poor.

MEDICAL AND OTHER TREATMENT

Recent modifications in the treatment of *non*-traumatic neuritis may here be briefly summarized, as it is my intention to avoid the more purely pharmacal side of the subject. Recognition of the fact that neuritis depends upon either malaria, diabetes, influenza, a preëxisting continued fever, intestinal torpor, syphilis, poisoning by a mineral, tobacco, or alcohol, would in itself supply the indication for orthodox drug remedies. In addition, radiant light and heat, followed by the static wave current with or without the static brush-discharge or static sparks, are to be applied over the aching nerve and spasmodic muscles just as when due to other causes.

Lately, bearing in mind the possible involvement of the island of Langerhans, some cases of the pancreatic variety of diabetes mellitus, when not secondary upon inflammatory adhesions from the bile-tract or an ulcer of the stomach or intestines, have been treated with a large metallic plate laid over the upper abdomen and actuated by the static wave current. The collection of cases with

results has not as yet been sufficiently large to formulate a definite opinion as to its value. Even in these cases, as also in diabetes of hepatic origin, the increased passive exercise of muscular fibre throughout the body, with consequent greatly accelerated metabolism and improved general nutrition, favorably influences the diabetic symptoms and, secondarily, the double-sided sciatica.

When neuritis depends upon a toxæmia from whatever source, the latter requires special treatment. Nasal sinusitis, alveolar pyorrhœa, purulent otitis, tonsillitis, bronchorrhœa, or any other bacterial or pus focus, must first be cured. (Here the complement-fixation tests for bacteria are useful for diagnostic corroboration.[5])

As previously mentioned, it may depend upon intestinal torpor with fecal resorption, one of the more frequent, even if seemingly remote, causes. Here, in addition to subjective symptoms of abdominal distress, there is often a history, that may necessitate careful questioning to elicit, of long-continued irregular defecation. Especially is this true when the patient depends upon purgatives to move the bowel. Surest proof of this intestinal intoxication is the heightened ratio between the conjugate and the preformed sulphates, a higher output of nitrogen (especially from urea) and of indican in the urine. In such event improvement should follow (1) an efficient course of high colonic flushings, with water or oil to remove impacted fæces; (2) the return of daily evacuations by the static induced current with the Snow rectal electrode within the rectum and a metal plate over the colon; (3) the giving of a salicylate or other intestinal antiseptic; (4) the application of a 500 c. p. hooded incandescent lamp over the abdomen for improved local tissue change, this followed by (5) the static wave current, a metal 8-by-12-inch electrode being placed diagonally below the ribs for this purpose. Where constipation depends on spasm of the sigmoid flexure (with possible spasm of the psoas muscle)[6] the new

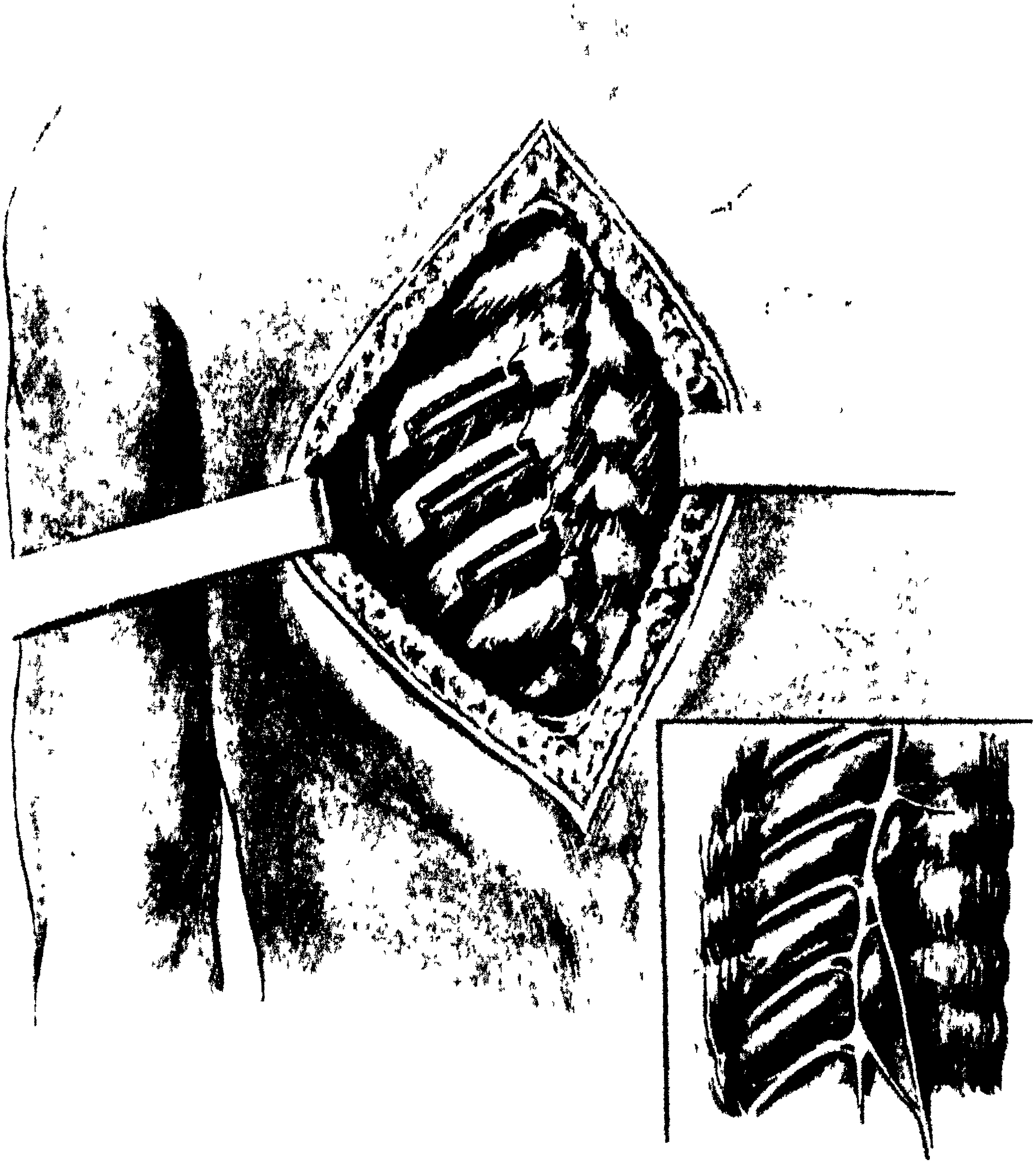
[5] Thomas Wood Hastings: "Complement-Fixation Tests for Streptococcus, Gonococcus, and other Bacteria in Infective Deforming Arthritis," *Jour. Amer. Med. Assn.*, April 19, 1913, pp. 1208–10.

[6] Carl von Noorden (*l. c.*) uses skiagrams of the region in diagnosis of sigmoidal spasm. As proof that "changes in the peripheral nerves and in the autonomous nerve system are in relation to the absorption of poisons from the intestinal canal," he claims indican to be present in excessive proportion, 50 to 100 mg. daily, instead of a norm of 20 mg., by the colorimetric method of Bouma. Ethereal sulphuric acid is not greatly increased in this variety.

sigmoid electrode suggested by Dr. William Benham Snow is indicated. A minimum protein dietary must not be overlooked. Uncomplicated high blood-pressure is lowered by auto-condensation.

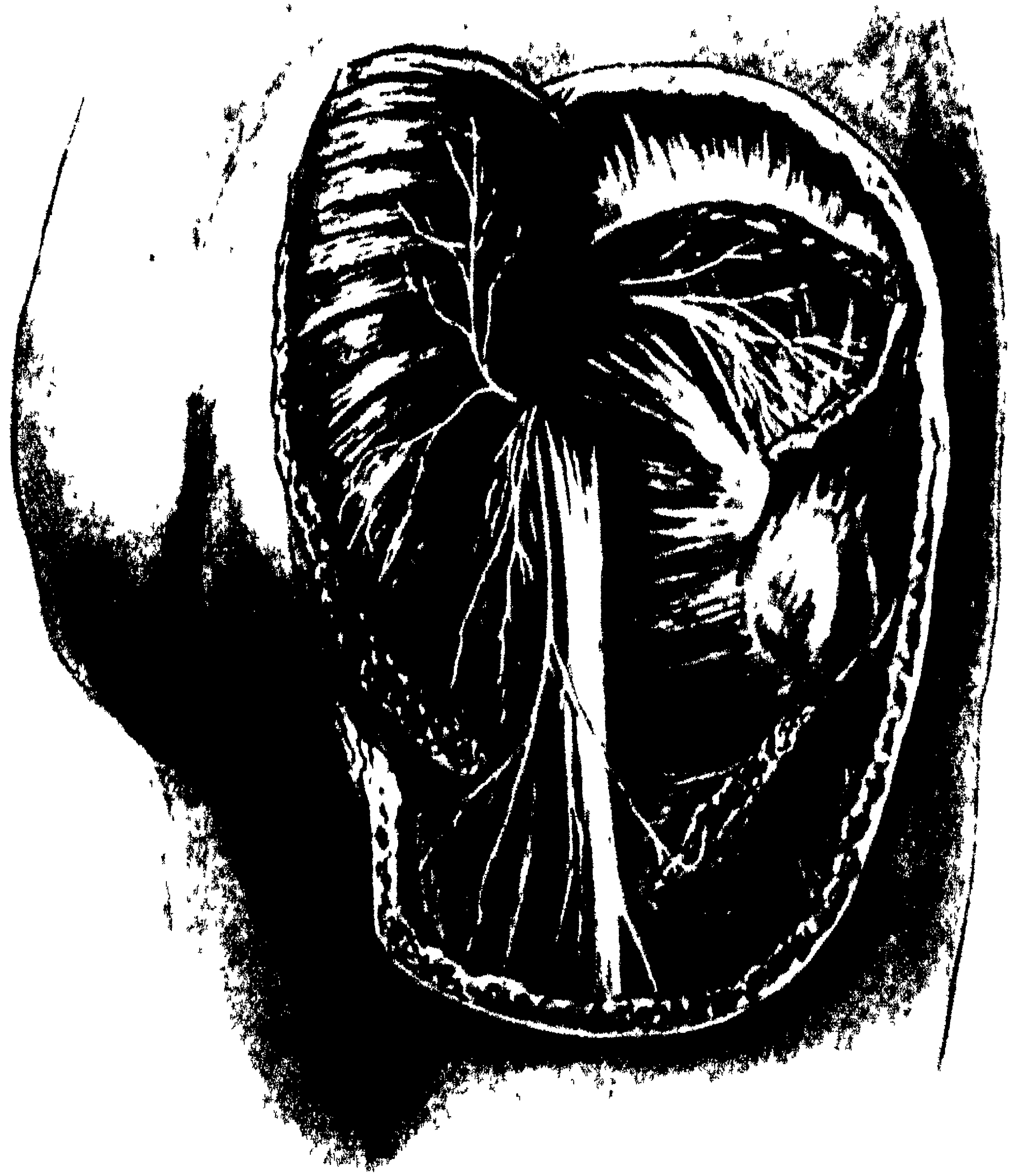
When consulted, however, for relief of neuritis due plainly to a trauma, the progressive physician realizes at the outset that removal of the plastic infiltrate is imperative—and here all the remedies in the pharmacopœia will fail him if mechanical methods are omitted. All the bakings, hydrotherapic and like measures will be insufficient if proper electric methods are forgotten. Locally, therefore, the chief indication is removal of the offending exudate through the static wave current with the same metal electrode bandaged over the affected nerve areas as was used in their localization; indeed, the diagnosis and treatment may thus be made continuous. Start, as already mentioned, with a small spark-gap, half an inch being as much as the aching nerve can probably endure at first. This gap length is gradually increased until twenty minutes have elapsed, this being the average treatment period, when probably two inches can be borne. The regular pulsatory contractions and relaxations of muscular tissue under the plate ensure like action on the foreign exudate, so that, after a series of such treatments, we may hopefully await the freeing of the imprisoned nerve. If, after each static wave application, muscles about the affected region are found to be in spasm, giving pain on motion or preventing free action of the member, these muscles receive static sparks until movement is free in all directions. The especial arrangement of the apparatus causes these sparks to be relatively painless. The current, thus stored in the body, is discharged where the electrode touches the spasmodic muscle, and clinical experience proves the disappearance of the spasm. In some of the more chronic cases quicker results have lately followed my preliminary use over the affected region of thermopenetration with the bipolar d'Arsonval current from the high-frequency coil apparatus. This "thermopenetration" of the affected tissues, resulting from a current having an enormously high rate of oscillation, small volume and relatively high pressure, throws a greatly-increased supply of blood into the area directly between the two electrodes. The resulting localized increase of blood may cause softening of the exudate and thus hasten its removal.

FIG. 5



Dorsal View.—The seventh, eighth, and ninth ribs are partly exsected to show their exact relationship to the corresponding intercostal nerves. Intrathoracic View.—The sixth, seventh, eighth, ninth, and tenth intercostal nerves are here shown in connection with the sympathetic nerves and ganglia. To influence neuritis in any part of the affected tracts the electrode should be placed alongside the corresponding vertebral spine.

Fig. 6



This dissection of the right gluteal region, the gluteal muscles being reflected, shows where the pyriformis muscle (at times spasmodically contracted from prostatic or uterine enlargement) bears down upon the aching sciatic nerve. This pain may be felt in any part of its course.

When neuritis is found about the face it is often necessary, in addition to, or as a substitute for, the static wave and static sparks, to resort to the static brush-discharge—especially when the lesion lies between the skin and bone, as about the forehead or under the scalp. The "effluve" or brush-discharge from the static machine permits of painless deep contraction of the soft structures without actual contact with the electrode. Indeed, the latter may be held at a distance of a foot or more, thus permitting its free use about the eye and other delicate organs. (Figs. 1 and 2.)

If intra-oral applications are needed to reach the affected nerve, the insulated glass vacuum electrode designed by Snow for tonsil or tongue is found to be most practical.

Herpes zoster calls for separate electric treatment, and here again the method generally advised by Snow will give the best and earliest results. Apply radiant light and heat to full hyperæmia over the whole area, firm vibrissage with a button vibratode upon the appropriate posterior nerve-roots, the static wave over the unerupted patches, and the static brush over the herpetic blebs. The rapidity with which this annoying disease then vanishes is almost uncanny. (Fig. 5.)

Brachial neuritis calls for radiant light and heat and then the static wave current, applied by a flexible metal electrode over the soft structures that cover the plexus between the clavicle and the scapula; it is here that inflammatory exudates are mostly found. Spasmodic muscles, already described, are then to have static sparks in succession until fully relaxed so that a free range of motion is possible. The patient, indeed, calls attention to the relief afforded and is sure to ask for renewal of the spark application. It is the customary practice of the writer to apply the indirect sparks from the static machine, satisfactory results usually following. Some colleagues, in addition, resort to the sparks obtained from the resonator attachment of the static machine for this object. The sparks obtained from the Tesla coil are found too energetic, therefore painful, for the average patient. (Figs. 3 and 4.)

Double-sided sciatic neuritis, when dependent upon prostatic or uterine hypertrophy, is curable, as a rule, on reduction of this enlargement. The metal rectal electrode, inserted sufficiently far into the bowel to permit its pressing firmly against the enlarged organ,

is connected with the static wave current; a half-inch spark-gap at start may be slowly increased, although a number of *séances* will be necessary before there is toleration of the required gap of four inches with which to begin the twenty-minute treatment. This holds true, in particular, for the spongy form of tissue excess. In the case, though, of hard fibrous change, should the continuous current, or thermopenetration from the coil, followed by the static wave, not effect a decrease, we may then resort to the Röntgen ray of suitable penetration, with the tube alternately over the perineum and above the pubes. These dense prostates respond with difficulty, but success may result, although operation is generally required. (Fig. 7.)

All other possible causes must sometimes be excluded when a neuritis proves purely rheumatic in origin. It is in this variety, especially, that the searching vacuum electrode with the static wave usually discloses organized neoplastic lymph about the posterior spinal nerve-roots. Here, in addition to using the static wave through a metal plate electrode, long-continued vibrissage is valuable to remove the exudate. (Fig. 5.)

Exactly the same facts hold true, as to diagnosis and treatment, in most cases of writer's cramp and other occupational so-called neuroses. The relief afforded these sufferers is marked and lasting.

So wide has grown the field for therapic use of the Röntgen ray that physicians begin to look askance upon its proposed newer applications that will not bear rigid scientific interpretation. A series of ten cases of sciatica is described by Delherm and Py [7] in which symptoms were marked and failed to respond to galvanism, the actual cautery, etc. Here the X-ray, applied on alternate days, gave full satisfaction, only one or two cases proving refractory.

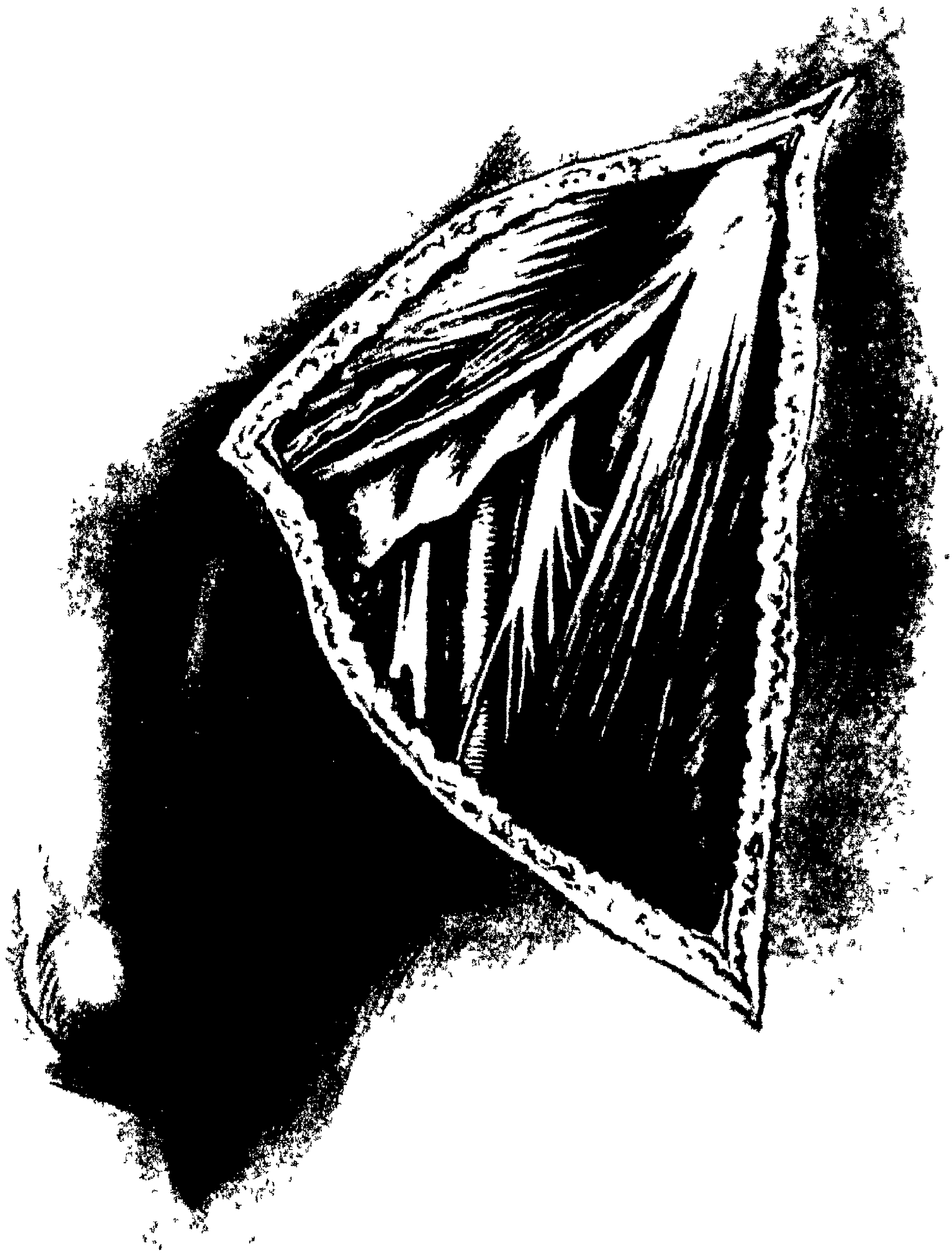
Patients are occasionally referred to electro-therapists because of an intractable sciatica or other pressure-neuralgia that depends upon an irremovable spinal growth or deformity, and here, when röntgenotherapy failed, the condition had heretofore been a deplorable one. The removal of pain due to this cause has taken on a different aspect since the new operation of rhizotomy was introduced,

[7] Chef Delherm and Eugène Py, of L'Hôpital de la Pitié, Paris: "The Radiotherapeutic Treatment of Sciatica," *Archives of the Röntgen Ray*, March, 1913.

Fig 7

In this anteroposterior section of the pelvis the view is toward the right side. The relationship between the bladder, the rectum, the prostate gland, the pubic nerve, and the sacral plexus with its distribution is here shown Reflex neuritic pain from prostatic hypertrophy is thus explained.

FIG 8



The anterior crural nerve is here shown lying in the upper part of Scarpa's triangle. The dissection above Poupart's ligament gives the position of the ilio-inguinal nerve and its relationship to the external oblique muscle, at times spasmodically contracted on the nerve, the lesion being hypertrophy of the prostate gland. In the dissection are also seen the external inguinal ring, the ilio-femoral nerve, the spermatic cord, the margin of the external oblique muscle, the anterior crural nerve, the femoral artery, the femoral vein, and the Sartorius muscle.

as Frazier[8] has lately explained. His enlightening address at the recent American Surgical Congress will prove most suggestive.

Because of the encouraging reports from Austrian, English, and German investigators, this subject would not be complete without at least mention of radium emanations for removal of neoplastic perineuritis. So far has this remedy obtained recognition abroad that the leading cities and spas of western Europe now have their "emanatoriums" in which radium-bearing gas is administered for this and other affections. America will in due time probably have like centres for this treatment, but at present its physicians distant from Philadelphia, New York, and a few other large cities must depend upon imported proprietary articles for the purpose. The remedy is given by the latter means either as drinking water,[9] in gelatine capsules, by hypodermic or intramuscular injection of the emanation in a saline solution, as a tub-bath, by compresses, or (also topically) as an earthy paste over the aching region. [Further information concerning this method will be found in the elaborate paper on "Radium," by Dr. William S. Newcomet, of Philadelphia (INTERNATIONAL CLINICS, vol. i, series 23).]

While, in conclusion, the methods just described would seem to call upon the doctor for much time and devotion to detail, it may be added that, based as they are upon personal experience, the gratitude shown by patients apparently condemned to hopeless invalidism is ample warrant for consistent and persistent efforts that must thus ensure success.

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[8] Charles H. Frazier: "Certain Problems and Procedures in the Surgery of the Spinal Column," *Surgery, Gynæcology and Obstetrics*, May, 1913. The literature of the subject is reviewed here.

[9] The U. S. Department of Agriculture has recently pointed out that waters containing radiant energy at the spring rapidly lose their therapeutic efficiency when bottled.

THE MANAGEMENT OF COMMON FORMS OF POISONING

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It is the purpose of the writer to describe the treatment of the common poisons in the light of their physiological action. As most toxic substances depress, either primarily or secondarily, the vital centres of the circulation and respiration, we shall outline in this first paper the methods of stimulating the circulation and respiration, and in the second discuss detailed treatment of individual poisons.

Respiratory Stimulation.—Perhaps the most common and typical respiratory depressant is illuminating gas. The toxic agent is, in the main, carbon monoxide. This gas is the active factor as well in so-called "fire-damp" and the poisonous mine gases. Carbon monoxide not only prevents the inhalation of oxygen, but it probably acts also as a direct depressant-poison to the vital centres. In the blood it forms carbon monoxide-hæmoglobin, and prevents the formation of oxyhæmoglobin, thus making it impossible for the red blood-cells to carry oxygen to the tissues. Carbon dioxide, on the other hand, is probably a stimulant within limits, both to the respiration and the vasomotor centre, and acts only mechanically by cutting off the supply of oxygen. It has many times been shown experimentally that an animal can breathe with perfect comfort in an atmosphere where the carbon dioxide is far in excess of that in ordinary air, provided sufficient oxygen is present and the air be not otherwise contaminated. It is, of course, well known that the determination of the amount of carbon dioxide in the air is the most practical method we have as to good or bad ventilation, but this is true only because the CO_2 is always proportionate to the amount of crowd poisoning present (this term is used to indicate a number of unidentified volatile organic substances that are found in expired air), and not because the carbon dioxide itself is poisonous.

Illuminating gas is by far the commonest form of attempted sui-

cide, and is said to cause more deaths than any other agent. The importance of the knowledge of the best method of treatment becomes obvious. Prevention, by having sufficient ventilation wherever slow combustion is taking place, is of great importance, but, given a case of gas poisoning, our first thought is to see that the patient has ample supply of fresh air. This is usually easily accomplished; but to get the fresh air into his lungs, if the respiration has completely ceased, is a much more difficult problem. Up to within a short time the well-known procedures of artificial respiration had been about all at our command, and actual studies of the amount of air thus moved indicate that they are grossly inadequate. When performing the Silvester method it is well to elevate the base of the chest with a roll of blanket. The tongue must be pulled forward so as to open the larynx, and the mouth must be kept free from mucus. The arms should be forcibly abducted and not simply lifted up and down, as is sometimes done. The abduction lifts the ribs and so increases the capacity of the chest. The rate of movement should not be over twenty a minute, and when the arms are brought down to the sides of the thorax they should be forced hard against the chest wall. It is an aid to have an assistant standing over the patient, and, as the arms are brought down, he at the same time presses with hands and knees against the lower ribs.

It is said by some that a better method than the Silvester is to turn the patient on his abdomen, with a roll under the epigastrium, turning the face to one side and having the tongue well drawn out. The operator stands straddle over the patient and, placing his hands on the base of the chest, his elbows against his own knees, he makes alternate pressure and relaxation at the rate of about twenty a minute.

As has been intimated, all these methods are inferior to directly forcing air into the lungs. A simple bellows attached to a rubber tube, with a glass T along its course, and at the end a face mask or laryngeal tube, is very commonly used in the laboratory for artificial respiration; the finger being placed on the end of the tube, when air is forced into the lungs and released for expiration. It is evident that great care must be exercised in getting the tube into the larynx rather than the œsophagus. Another important precaution is that the pressure on the bellows must not be too great, as rupture of the lung may re-

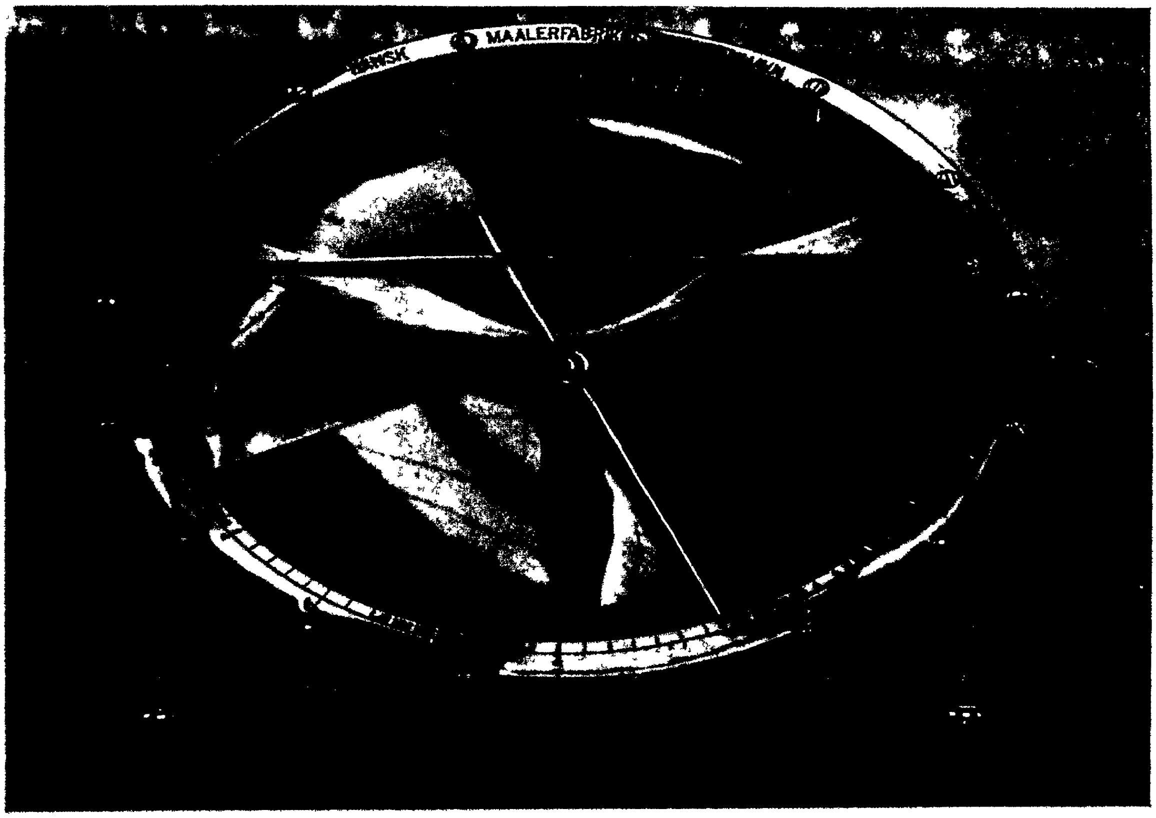
sult. If a face mask is used or the mouth-to-mouth method practised, great care is necessary that the air does not simply pass into the stomach. This point will be taken up in detail later.

The pulmotor, the latest and probably the most efficient invention for artificial respiration, consists of a tank of oxygen under high pressure, connected with an automatic respiratory apparatus, the pressure of the oxygen giving the motive power, the rate changing automatically with the size of the lungs, and the pressure never becoming excessive. The apparatus is connected with an air-tight mask by two flexible tubes of large calibre, one for inspired, the other for expired air, so that each time the pulmotor works the patient takes in a fresh supply of oxygen. The mask is held tightly around the face by a metal ring covered with rubber, to which are attached four rubber straps under tension. If the mask does not fit tightly the pulmotor will not operate. It is evident that no air can enter the lungs unless the tongue is drawn well out, thus pulling the epiglottis forward. The mask, therefore, must fit tightly around the tongue, the end of which protrudes from below the mask, and unless the lower teeth are covered with a small pad the tongue is likely to be badly cut. If, now, the mask fits securely all around and the pulmotor is started by simply opening the oxygen tank, being sure that the word pulmotor is turned upward on the switch valve, the instrument will automatically start.

If the patient is an adult, and the machine works very rapidly, the larynx is closed and the oxygen is simply passing in and out of the mouth. In many cases the air will not go into the lungs but into the stomach, as has been said. This can be detected by listening with a stethoscope over the epigastrium, or simply observing the movements in this region. As the air is passing into the lungs through the trachea, distinct respiratory movements can be seen.

The œsophagus being a flexible tube and easily compressed, while the larynx and trachea are semi-rigid, it has been shown that by making pressure with the finger over the larynx the œsophagus may be kept closed, without collapsing the trachea, through which air will freely pass into the lungs. As will be seen by examining the instrument, there is arranged on the cover of the pulmotor case a simple oxygen inhaler without artificial respiration, the idea being that,

Fig 1



Gasometer.

after the patient has started to breathe voluntarily, oxygen inhalation may be continued.

The case is fitted with a separate mask for this purpose. During the working of the pulmotor the patient is breathing almost pure oxygen. The apparatus will run about forty minutes in succession if started with a full-charged tank. It can be easily carried by one man, the weight being about forty pounds.

This instrument is useful in acute paralysis of the respiration from any cause, particularly in the following poisonings: illuminating gas, ether, chloroform, and opium. The instrument would be improved by a method of artificial respiration which gave to the patient only the amount of oxygen found in the normal air, as it is still a question whether the blood will continue to take up oxygen from the lungs, when breathed for a long time, in concentrated form. Further, in cases of opium poisoning it is often necessary to keep up artificial respiration, the patient breathing normal air for two hours or even longer, before voluntary breathing is established.

As to the drugs that stimulate the respiratory centre, mention has already been made of the carbon dioxide, and it is believed by some that inhalations of this gas are valuable in depression of the respiratory centre. Of the alkaloids, atropine sulphate, gr. 1/100, and strychnine sulphate, gr. 1/30, cocaine hydrochlorate, gr. ¼, and caffeine sodium benzoate, gr. 2, are probably the most effective stimulants to the respiration.

It is apparent, however, that, if the circulation has completely stopped, the hypodermic or even intravenous use of these drugs can be of little benefit, as they will not reach the vital centres. The value of the older reflex methods of stimulation must not be underestimated, such as sudden applications of cold, stimulation of the conjunctiva, inhalations of ammonia, etc.

An instrument called the gasometer has been devised (Fig. 1) by which the amount of expired air during each expiration can be measured. During anæsthesia, if, at regular intervals, the patient breathes into this, beginning failure of the respiration may be noticed by the lessening amount of air expired.

Stimulation of the Circulation.—In acute circulatory failure from a toxic agent, such as ether or chloroform, the immediate lowering of the head is a well-known procedure. The mechanism by which this

stimulates the heart can be easily understood by recalling that, in shock, the mass of blood is in the great venous sinuses. The inversion of the patient throws this blood back into the right heart, thus stimulating it and starting its pulsation.

Reflex methods are here of value, as in respiratory failure, and particularly ammonia. It is very doubtful if sufficient of this drug is ever absorbed so as to produce direct cardiac stimulation, but as an indirect stimulant its action is prompt and effective. This can be very well shown experimentally, for if an animal, whose carotid artery is connected with a mercurial manometer, is made to inhale ammonia, a very decided rise in the blood-pressure is produced, which lasts over a considerable time.

As already mentioned, hypodermic or intravenous injection, when the circulation has entirely ceased, is useless, but if there be a slight movement of the blood-current, five to ten minims of a 1-1000 solution of adrenalin is very active, though transient. It may be given hypodermically in the loose tissue below the clavicle, or, better, intravenously. This, of course, is much more difficult, and especially so if the blood-pressure be very low. If a wide bandage is placed above the bend of the elbow tightly enough to stop the venous circulation alone, the superficial veins will obviously become much more prominent, and if a short needle is used, the introduction into the veins is easier. A glass syringe should be employed for this purpose, because when the needle has successfully entered the vein the blood will immediately back up in the syringe.

The intravenous injection should be given very slowly, occupying three or four minutes. The effect is to directly stimulate the heart muscle and to contract powerfully the blood-vessels peripherally, and may be followed by secondary depression. The digitalis group, as is well known, contains the most powerful drugs we have in the treatment of circulatory depression of cardiac origin. Digitalis, however, is locally irritant, and its glucosides are uncertain. Ten minims of the tincture of digitalis given deeply into the muscle has a definite stimulating effect, but will probably produce an abscess.

Digalen, said to be soluble digitoxin, can be given in doses of ten minims. It produces no local irritation, but its action upon the circulation is not proved. Strophanthin is being used a good deal of late and undoubtedly has a powerful stimulating effect on the heart

muscle. It may be given intravenously with great caution, and, in desperate cases, in doses of 1/1000 gr. in solution. Strophanthin Boehringer is probably the best preparation to use, which is dispensed in sealed ampoules, each one containing a dose.

Pituitrin, the active principle of the pituitary body, has much the same effect as adrenalin. There are also numerous hypodermic preparations of ergot on the market, which have a very marked effect upon the circulation—mainly by stimulating the vessels peripherally.

The author has used tyramine[1] (*p*-hydroxyphenylethylamine) in doses of twenty or thirty milligrammes, producing in the human being a very marked effect upon the blood-pressure, but, like adrenalin, very transient. The effect of atropine upon the heart-rate is mainly due to peripheral paralysis of the vagus. It is of value in the early stages of digitalis, chloroform, and opium poisoning, and has also a distinct vasomotor central stimulant action. Strychnine, so largely used in circulatory failure, produces experimentally only a slight rise in the blood-pressure, and, when applied to the isolated mammalian heart, very little stimulating effect can be shown.

It is possible, by the resuscitation method of Crile, to revive an animal after the heart has stopped for seven minutes, by the following method:

Under ether and morphine anæsthesia, dissect out both carotid arteries. Into one a cannula is placed connected with a mercurial manometer. A stylus floats on the mercury and makes a record of the pulse-rate and blood-pressure on smoked paper, kept in motion by a kymograph. The ether is now pushed until the pulse ceases and the blood-pressure falls to zero.

A second cannula is placed in the other carotid artery and connected with a bottle containing two or three hundred cubic centimetres of normal salt solution at 100° Fahrenheit. The tube connecting the cannula with the bottle is about 6 feet in length, the bottle having an opening at the bottom. As soon as the circulation ceases the arteries become empty. From a height of 6 feet the salt solution is allowed to flow into the artery toward the heart, the flow, therefore, being in the opposite direction to the normal blood current. The salt solution flows back into the aorta and closes the aortic valve. It will

[1] "The Therapeutic Application of Tyramine," *Transactions of the College of Physicians*, Third Series, vol. xxxiii.

be remembered that the openings for the coronary arteries are immediately in front of the aortic cusps. The salt solution, being stopped by the closed valve, enters the coronary arteries and is thus carried to the cardiac muscle. After 100 Cc. have flowed in, the rubber tube just above the cannula is punctured with a hypodermic needle and 1 Cc. of 1–1000 adrenalin solution is quickly injected. This is carried in bulk through the coronary arteries to the heart muscle. At the same moment external massage of the thorax is done the heart will begin to pulsate and if artificial respiration be continued the animal will recover.

If the heart has stopped for only seven minutes, it is possible to bring about a complete recovery, but if a longer time has elapsed, though circulation and respiration may be started, the animal never regains his complete mentality; he is always stupid, because certain degenerative changes have taken place in the brain-cells during cessation of circulation, from which they never recover. The author has seen this experiment carried out many times on the dog, and it has been successfully accomplished in the human being in cardiac failure due to shock or prolonged anæsthesia.

It is obvious that such a method can only be useful when the tissues themselves have not undergone profound pathologic change. In certain types of poisoning, therefore, particularly chloroform and ether, this method is coming into use.

The intravenous injection of normal salt solution in shock is so well known that it requires little comment. The addition of 10 minims of 1–1000 adrenalin to the salt solution, however, is often useful, keeping in mind that adrenalin stimulation is often followed by secondary depression. Alcohol is sometimes used as a stimulant following prolonged ether anæsthesia. So far as the experimental evidence goes, it tends to show that the action of alcohol and that of ether are almost identical, and that if ether has already produced depression, alcohol increases this. Camphor in 2-grain doses dissolved in 10 minims of sterile olive oil is largely used in cardiac failure, and there seems to be much clinical evidence in its favor. Experimentally, however, camphor produces little effect upon the normal heart, though there is some reason to believe that when the heart is depressed by chloral, camphor will stimulate it.

AUGMENTED BLOOD-PRESSURE

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SPHYGMOMANOMETRY is definitely established as an important aid in diagnosis. Hypertension is frequently a defensive reflex phenomenon, like a muscular spasm, which immobilizes a joint, and unless this conception is entertained reduction of pressure may often lead to disastrous results.

Blood-pressure is most evident in the arteries, and less so in the veins, whereas in the capillaries it is intermediate between the arteries and the veins. In consequence of the foregoing, the blood circulates continuously in the direction of the arteries to the veins.

Arterial pressure or tension is made up of a multitude of factors, but the essential ones are ventricular pressure and peripheral resistance. The primary factor is the force of ventricular systole, and any increase in the volume output eventuates in a rise, and conversely in a fall, in pressure, assuming there is no change in peripheral resistance.

Blood-volume has only a subordinate effect on pressure, inasmuch as when the volume is diminished peripheral contraction of the arterioles maintains the pressure. When the volume is augmented, the compensatory mechanisms are: Dilatation of the vessels, transudations, and increased activity of the secreting organs. When peripheral resistance is much increased, there is a diminution in the volume-output of the ventricle.

Finally, another protective mechanism exists in the ventricular wall itself. The abnormal tension of the latter in high blood-pressure causes an automatic fall of pressure by stimulation of the filaments of the depressor nerve.

In peripheral resistance there are likewise a number of subordinate factors, but the essential factor is arterial elasticity. In the norm the latter with its systolic and diastolic activity diminishes the work of the central organ, and may be regarded as a peripheral heart.

The abdominal vessels innervated by the splanchnic nerves exercise the most pronounced influence on the general blood-pressure, and they are sufficiently capacious to hold practically all the blood-volume of the body. Surgical shock has been attributed to such accumulation of blood in the abdominal vessels owing to exhaustion of the vaso-motor centre, and this shock may be prevented by injections of nerve-trunks with local anæsthetics prior to an operation. More recently the reduction of CO_2 in the blood (acapnia) has been suggested as the cause of shock.

Blood-pressure, like temperature and respiration, is subject to physiologic fluctuations. It is likewise influenced by posture, emotion, and muscular exertion. In women pressure is approximately 10 to 15 mm. lower than in men. In athletic men it may be 10 to 15 mm. higher than in those of moderate development. Age also influences pressure. A pressure above 160 mm. is seldom observed in the norm, while a pressure above 200 mm. signifies very high tension.

One may roughly estimate the normal pressure by allowing 1 mm. of mercury for every year after the age of 15, and adding 100 to the number. Thus, in this patient, whose age is 60, one would expect a normal blood-pressure of 160 mm. For all practical purposes it suffices to estimate the systolic pressure, inasmuch as it is more often modified by pathologic conditions than the diastolic pressure.

All observations must be made with the subject in the same position. The wide arm-piece (12 cm.) should fit accurately and be applied at the heart-level, the connections should consist of non-distensible tubing, and it is wise to employ an instrument which measures both systolic and diastolic pressures.

The estimation of venous pressure is as yet of little clinical value. You may determine it by stroking a vein until it becomes empty up to a valve, and then note with the sphygmomanometer the pressure at which the vein fills.

To obviate the possibility of mistaking the pulsations in the examining finger for those of the patient, I use a rubber ring at the base of my index-finger to exclude the blood.

From what has preceded, the conditions increasing arterial blood-pressure are:

1. Augmentation of the rate or force of the contraction of the heart.

2. Augmentation of the peripheral resistance.

3. Augmentation of the force of the heart and peripheral resistance.

Reverse the preceding factors, and you have conditions propitious to a decrease of the arterial blood-pressure.

I shall attempt only a brief survey of the etiology of hypertension.

Pains of all kinds provoke high pressure by reflex stimulation of the vasomotor tone. You may utilize this fact in the diagnosis of genuine pain in malingerers. You know that pressure on a sensitive area will likewise increase the pulse-rate and dilate the pupil. During labor, pain and the augmented volume of blood sent to the heart by compression of the abdominal vessels are responsible for hypertension. Menorrhagia, notably at the menopause, is often associated with high pressure due to arteriosclerosis of the uterine vessels. Epistaxis may be the first evidence of increased blood tension.

Drugs like strychnine, digitalis, adrenalin, and other cardiotonics act by increasing either the peripheral resistance (vasoconstriction), or cardiac energy, or both. Vasoconstriction is evoked by toxic conditions like gout, uræmia, plumbism, nicotinism, and some psychoses.

In renal diseases the notable factors causing hypertension are cardiac hypertrophy and increased peripheral resistance due to a vasomotor spasm provoked by the irritating action of waste-products in the blood, or degeneration of the peripheral vessels, or both.

A high and rising pressure in cerebral hemorrhage indicates more bleeding and progressive failure of the circulation in the medulla. Insomnia caused by autointoxication is associated with hypertension. In chronic pulmonary tuberculosis a normal or increased pressure indicates a favorable prognosis. In the differential diagnosis of gouty symptoms a high pressure argues in favor of the latter.

Albuminuria is probably of renal origin if there is hypertension.

In neurasthenia due to enterotoxins pressure is usually high. A high pressure is not infrequent in melancholia, and improvement in the mental symptoms is synchronous with a fall in pressure. In mania the pressure is inclined toward subnormal levels.

Anginoid pains associated with hypertension are probably due to organic disease, arteriosclerosis being the condition most commonly associated with hypertension.

It is advisable to differentiate the conditions contributory to hyper-

tension. In 1904 [1] I investigated the vasomotor factor in the clinical measurement of blood-pressure, and found the resistance offered by the blood-vessels to be a paramount factor. If the vessels are dilated the pressure falls, and if contracted it rises.

My investigations permit me to formulate the following conclusions:

1. The chief constituents of blood-pressure are ventricular force and vasoconstriction.

2. Inhalation of amyl nitrite dissipates the vasoconstrictor factor and brings into action the ventricular force.

3. The vasoconstrictor factor is frequently a defensive reflex phenomenon to compensate ventricular inadequacy.

When the blood-pressure is taken it is ordinarily difficult to estimate how much is due to vasoconstriction and how much to the condition of the myocardium. The heart may be insufficient, yet hypertension be present owing to the vasoconstriction which compensates a failing heart. My method of differentiating these two factors is as follows:

Estimate the blood-pressure; next have the subject inhale amyl nitrite until its physiologic action is manifested (flushing), then take the pressure again. In the norm the average increase of pressure after the inhalation is from 6 to 10 mm.

In cardiac enfeeblement a fall in lieu of a rise ensues, and the degree of fall is in proportion to the degree of myocardial insufficiency. The dictum of the physiologist that the nitrites lower blood-pressure is not borne out by my clinical investigations. In the norm amyl nitrite causes a temporary fall of pressure, but the systolic pressure immediately rises. After investigating a large number of arteriosclerotics, I have classified them as follows:

1. Those with hypertension in whom amyl nitrite inhalations produce a slight rise or stable pressure. Here the myocardium is not yet compromised.

2. Those with high pressure which diminishes after using amyl nitrite. In this as well as the succeeding class reduction in tension is caused by elimination of the tonus of the vessels. Elimination of the latter permitted the true endocardial pressure, which was enfeebled, to be brought into action.

3. Those with low pressure, which is accentuated after using amyl

[1] *The American Journal of the Medical Sciences*, Nov., 1904.

nitrite. These arteriosclerotics belong to the hopeless category, inasmuch as the vasomotor mechanism is either exhausted or unable properly to usurp the functions of a failing heart.

In typical instances of arteriosclerosis one finds hypertension associated with thickened arteries, hypertrophy of the left ventricle, and accentuation of the diastolic aortic sound or prolongation of the first sound. Not infrequently a mitral leak may appear.

Vasomotor sufficiency may be tested as follows:

Take the pressure first in the recumbent and then in the erect posture.

There is a postural variation in the norm. In the erect posture the pressure rises owing to compensatory arteriole contraction, and this variation according to my measurements is between 15 and 30 mm.

In vasomotor insufficiency the postural variations are reversed. An insufficient vasomotor system may maintain a high blood-pressure owing to accumulation of blood in the splanchnic vessels. The splanchnic vasomotor system is the latest in the body to develop, and it appears only after man has taken to the erect position.

The following is a record of an adequate automatism of the splanchnic vasomotor mechanism:

	Pulse-rate	Systolic pressure
Lying	58	120 mm.
Standing	58	132 mm.
Difference	0	+12 mm.

The following record demonstrates an insufficient mechanism:

	Pulse-rate	Systolic pressure
Lying	68	100 mm.
Standing	104	94 mm.
Difference	+36	—6 mm.

In the treatment of hypertension it is equally your duty to determine what will do the patient harm and what will do him good. It is, therefore, imperative to bear in mind the fact that hypertension is essentially a symptom, and not infrequently a compensatory phenomenon, which must be maintained and not subdued. When my method of treatment for supernormal pressure fails it is often due to a failure to subdue the etiologic factor concerned. The latter may be

renal, cardiovascular, or due to excessive formation of enterotoxins. Among less common factors are anomalies in the splanchnic area and augmented secretion of pressor products by the adrenals. Other hypertensive substances, imperfectly understood, likewise contribute to the etiology of augmented pressure.

It is definitely established that vasoconstriction is effected by adrenalin. If the suprarenal veins are clamped the pressure falls, and rises again when the clamp is removed and the adrenalin is released into the circulation.

It must be ascertained whether syphilis, alcohol, plumbism, gout, or other conditions of faulty metabolism exist.

Here is an instance of an individual with a blood-pressure of 260 mm. In his case renal insufficiency was present, and reduction of the hypertension was contraindicated.

In estimating the urea in the urine one must remember that its percentage varies with the amount of proteid food ingested. Before concluding that the urea is diminished (hypoazoturia), an ample mixed diet should be given. If during one day a test diet of 500 grammes of meat, 8 eggs, and 200 grammes of bread (a total of 172.25 grammes of proteid) be given, the normal excretion of urea should be 59 grammes.

This amount of urea was excreted with a pressure of 260 mm. When the latter was reduced to 200 mm. the amount of urea excreted while on the diet in question amounted to 30 grammes, and the patient suffered from the minor symptoms of uræmia. On a purin-free diet only, the pressure fell to 220 mm.

The term hyperpiesis refers to high pressure alone, without evidence of cardiovascular disease.

Here one finds the supernormal pressure to be due to augmented tonus of the vasomotor centre; it is often essentially a nervous phenomenon.

The latter, which I have neologized as psychogenic hypertension, often yields to large doses of bromide, carried even to bromidism if necessary.

Hyperpiesis in children is not infrequent and is characterized, as in adults, by the symptoms of gastro-intestinal digestion. In both instances a correct dietary and fractional dose of calomel will often yield phenomenal results.

It is practically impossible to recount the many methods advocated for reducing pressure, and much ingenuity has been displayed in advocating the different modes. Rumpf's theoretic conception of checking arteriosclerosis by reduction of the lime in the ingesta and the administration of lactic acid to dissolve the lime in the blood-vessels, has been of no service in practice.

The drugs chiefly employed for this purpose are the vasodilators which paralyze the vasomotor mechanism, among which the following are in use:

1. Amyl nitrite, which is too transitory in action.
2. Erythrol tetranitrates (tetranitrol). Effects appear in an hour, and last about five hours.
3. Nitroglycerin (trinitrin). Acts in two or three minutes, and its effects rarely last more than three hours.
4. Sodium nitrite, which corresponds to the latter in action.

Potassium iodide, which manifests its vasodilator action only after prolonged use. This agent also acts by diminishing the viscosity of the blood, and for the latter reason it is effective when the vascular supply of an organ is diminished.

I have employed the following to reduce pressure:

Powdered stramonium,
Powdered belladonna,
Powdered hyoscyamus,
Powdered potassium nitrate, āā, 1 oz.

Mix. Burn one-half teaspoonful or more and inhale fumes two or three times daily.

The relatively good results secured were no doubt effected by the last ingredient, which alone is capable of reducing blood-pressure.

A combination for internal use which is often effective is made up of sodium nitrite, potassium nitrate, and sodium hippurate.

Pharmacotherapy is, as a rule, unsatisfactory in hypertension for the reason that toleration for the vasodilators is rapidly acquired, and their action is evanescent.

From the preceding we are constrained to conclude that hypertension may be a salutary condition to compensate a failing heart, and the vasodilation would be injurious. The correct thing to do in such instances is to fortify the heart, and the blood-pressure will fall of its own accord. This effect may be rapidly achieved by concussion

of the spinous process of the seventh cervical vertebra, or more slowly by the administration of digitalis or other cardiotonics.

Here is a subject in whom this method may be illustrated. Examination shows marked cardiac enfeeblement and a pressure of 230 mm. After concussion of his seventh cervical spine for one-half minute you will note that the pressure has fallen to 200 mm. In this case the hypertension is an expression of cardiac enfeeblement, and the course to pursue is to strengthen the heart. In the senile arteriosclerotic the heart is endowed with little or no reserve power, and all endeavors to fortify it may be fruitless.

In the majority of cases, in my opinion, the most effective method of reducing pressure is by concussion between the third and fourth dorsal spines, for at this point we stimulate the depressor nerve. When tension is excessive in the heart and aorta, the nerves arising from the latter are stimulated and cause reflex stimulation of the abdominal vessels. The nerves in question may be the distinct structures known as the depressor nerves or may be incorporated in the vagus.

The splanchnic area is one of the largest vascular districts in the body and is, perhaps, the chief regulator of blood-pressure.

If the portal vein be tied, practically all of the blood in the body accumulates in the hepatic and intestinal vessels, so that an animal may be bled into its own veins.

If one percusses the lower abdomen immediately after concussion between the third and fourth dorsal spines, areas of dulness caused by dilatation of the splanchnic vessels may be elicited.

Stimulation of any centripetal nerve augments blood-pressure; the essential factor in this reflex is a vasoconstriction in the splanchnic area, the only exception to this being stimulation of the depressor nerve, which diminishes pressure by dilating the splanchnic vessels.

You may frequently observe that the primary result of concussion in the region cited is an evanescent rise of pressure followed by a decided fall, which reaches its lowest point in about two hours.

Daily *séances* not exceeding ten minutes are necessary for this treatment. Concussion periods should not exceed a half-minute, with rest intervals of the same duration of time. Thus, in a *séance* as mentioned, there will be five minutes of treatment and five minutes of rest.

The value of this treatment can be decided the same day. If,

two hours after concussion, there is no fall in pressure, it is useless to continue the treatment.

You may secure etiologic diagnostic help from hypertension. Thus, in cerebral arteriosclerosis, the subject may have headache, vertigo, transient paresis, or aphasia. If, following concussion, blood-pressure is diminished and the symptoms have abated, the diagnosis is suggested.

Abdominal arteriosclerosis is frequently overlooked. In all individuals over the age of 40 years paroxysmal abdominal pains, notably after exertion or emotion, should suggest arteriosclerotic abdominal colic.

The paroxysms may last from a few minutes to a half hour, and generally awaken the subject from sleep. The pains may radiate as in true angina. The abdominal aorta is usually sensitive to pressure, but continued moderate pressure will relieve the pain. The gastric crises of tabes, of abdominal angina, and of lead colic are the only forms of acute abdominal pain associated with augmented blood-pressure.

There are two drugs which are almost specifics for the relief of pain and reduction of blood-pressure in this condition: theobromine sodium salicylate and strophanthus. In my experience the former is the more effective, especially if supplemented by rest in bed, when given in doses of from 15 to 20 grains three times a day. The full action of the drug is not secured until the third day. Untoward effects, if any, are headache and gastric disturbances, due, no doubt, to its salicylic acid constituent.

Rest in bed is one of the most important aids in the treatment of the hypertensionist. One not infrequently observes that a blood-pressure of 200 mm. or more when the patient is up and about may decline to 140 mm. or less when he is at rest in bed. This is important, inasmuch as continued hypertension may conduce to arteriosclerosis.

Cold weather increases and warm weather diminishes pressure; hence the advantage of a temperate climate. One may assume that the cold, in the former instance, conduces to spasm of the arteries and capillaries and thus raises the pressure.

Medicine

AZUROPHILE MICRO-ORGANISMS

ETIOLOGICAL STUDIES ON RABIES, POLIOMYELITIS, AND VARIOLA

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By means of modern bacteriologic and microscopic methods it has been found that the causative micro-organisms of infectious diseases can be divided into two groups: First, those which can be seen microscopically and can be cultivated; second, those which are either difficult or impossible to demonstrate by ordinary microscopical methods, and, in contrast to the first group, the majority of which are filterable.

In 1898, Löffler and Frosch [1] first demonstrated the filterability of the unknown virus of the so-called foot-and-mouth disease of cattle. In 1899, Nocard and Roux [2] showed that the same was true of the peripneumonia of cattle. After these demonstrations, a new class of micro-organisms were called filterable, invisible, or ultramicroscopical viruses, and subsequently the virus of all infectious diseases of unknown origin were tested for filterability.

The claim is made that the virus of the following infectious diseases [3] of man, of animals, and also one of plants are filterable: Yellow fever, verruca vulgaris, trachoma, poliomyelitis, typhus fever, sand-fly or three-day fever, and measles. This is also claimed of a few diseases which are common to both man and animals, such as foot-and-mouth disease, rabies, vaccinia, and variola; and of diseases of animals, such as peripneumonia of cattle, African horse sickness, swamp fever of horses, agalactia contagiosa of sheep (blue tongue), cattle plague, sheep-pox, pernicious anæmia of horses, dog distemper, stomatitis papulosa bovis specifica, guinea-pig epizoötic, a peculiar paralysis of guinea-pigs, fowl pest, fowl diphtheria, which is identical

with the epithelioma contagiosum of fowls, leukæmia of fowls, and fowl sarcoma; of plants: the mosaic disease of tobacco.

As usually believed, does the filterability of a virus mean microscopical invisibility? To answer this question, we must consider, first, the limit of microscopical visibility; second, the reliability of the filtration, and, third, its staining properties.

LIMIT OF OPTIC VISIBILITY

The mathematical estimation of Abbe and Helmholtz has shown that by the largest opening angle, 180°, and the use of white light and central illumination, the smallest distinguishable object size is 0.55 μ, or respectively 0.27 μ by slant illumination. With dark-blue light, the wave-length G of the spectrum would be 0.43 μ, or by slant illumination 0.21 μ, the lowest limit for direct microscopical visibility.

The darker violet light would be somewhat favorable, but is not considered because the human retina is not sensitive to this ultraviolet spectrum. On the other hand, through the medium of photographic plates which are sensitive to ultraviolet rays, which have the greatest chemical effect, we can make those which fall slightly below the limit of visibility indirectly visible.

The limit of direct visibility, 0.21 μ, cannot be transgressed regardless of further perfection in lens systems, as all objects which fall below this limit cannot be made visible.

Whether the microphotography with monochromatic ultraviolet light, having one-half the wave-length of yellow light as inaugurated by Koehler, is of value in making visible those micro-organisms which are invisible for direct sight remains to be tested.

According to Koehler,[4] ultraviolet rays would not only double the resolving power of direct microscopical visibility, but would make it possible to photograph objective sizes of 0.1 μ and also make protoplasmatic structures visible which lie within direct visibility but cannot be seen on account of high refraction. The ultraviolet rays are specially absorbed from such organic media. The ultra microscope and the dark-field method of illumination will be of no value in studying the filterable viruses, because it is impossible to dis-

tinguish the innumerable small particles which represent organi fluid contents from the micro-organisms.

The following is a table of comparative sizes:

Lower limit for drawing with naked eye	0.1	micro
Wave-length of red light (Line *A*)	0.76	micro
Wave-length of yellow light (Line *D*)	0.59	micro
Wave-length of blue light (Line *G*)	0 43	micro:
Wave-length of violet light (Line *H*)	0.39	microi
Distance between gas molecules	1.0	microi
Size of polyatomic molecules	0.3 to 0.8	microi
Lower limit of the molecule's size (one atomic molecule)	0.03 to 0.05	microi
Size of red blood-cell	7.5	micra
Tubercle bacillus	2 to 4	micra
Spirillum parvum	1 to 3	micra
Influenza bacillus	1.2	micra

FILTRATION

I wish to discuss the phenomena of bacterial filtration, filtration in general, and whether it is justifiable to believe that filterability of virus means microscopic invisibility. The works of von Esmarch and Rosenthal [5] are the most comprehensive on the phenomena of bacterial filtration.

It is necessary to begin with the definition of a filter. To separate particles in a rough mechanical way we use sieves or filters. We can define the sieve as a perforated plate or lattice, its thickness unimportant, but the openings of uniform size, which is used for separating large particles. For finer particles different kinds of filter-paper are used, and, for minute particles, dialyzation membranes. Further, we have semipermeable membranes for dividing the smallest molecule on the limit of ultra visibility from colloidal suspension. A rough mechanical explanation of the latter is impossible, as the size of the particle and certain physical and chemical conditions play a rôle between the particles and the membrane.

For the larger intermediate zone between well filterable precipitates and the finer colloidal particles between 20 μ and 20 $\mu\mu$, or 1/1000 smaller particles, we have no filter. Probably the ultrafilters invented by Bechhold will fill this vacancy. For filtration of bacteria and the different viruses we use filters of porous material. These may be either of unglazed porcelain, such as the Pasteur-Chamberland, which is manufactured in two forms, B and F, or of

infusorial earth (fossil meal, Kieselguhr), such as the Berkefeld-Bitter, made in three different porosities, which are designed N, V, and W (normal, quick and slow flow), filter V being chiefly used for bacterial filtration. The Pukal filter, made of hard-baked clay, is seldom used.

The density of the filters depends upon the baking, and each new filter mass must be tested. For the comparative study of filters, only new ones should be used. Filters which are washed and burned have their porosity changed in an unaccountable way, but their utility depends on the thickness of the filterable layer.

If we consider the porous filter as a combination of a large number of sieves with openings of different dimensions, each sieve would retain only such bodies as are larger than its largest openings. If we pile many such sieves together, it is probable that few of the larger particles would pass through, and on thorough shaking the smaller ones would stick between the sieves. This explains why filters made of a desired thickness from a certain porous mass are dense enough for certain bacteria, and when made of less thickness finer bacteria are largely but not completely retained.

In reality, we do not deal with piled sieves, but with a system of many kinds of communicating canals of continuously changing calibre; or, to be more exact, with spaces of innumerable shapes connected by many small clefts. It is questionable, however, whether all the phenomena of these filter masses can be explained in this way. There appear to be other conditions. For instance, by pressing certain bacteria through the filter, the filter is completely clogged, but can be penetrated by the same bacteria. For example, if both sides of the filter are moistened with bouillon, and we inoculate one side with bacteria, they will in time pass through. Esmarch claims that irregularities in the structure of these filters are responsible for this condition. He could show microscopically on sections of filters spaces which sometimes are so extensive that in some places the apparently solid filter mass consists only of two thin walls. He also showed much finer irregular canals, and demonstrated the growth of bacteria on sections of filters which were stained with carbol-fuchsin.

Rosenthal, on section of filter plates, found minute clefts no larger than one micron. These were probably due to air bubbles

produced during the manufacture of the plates. They were always parallel with the surface of the plates.

By pressing brazoline stained with aniline violet through filters, with low power the section shows fine meshes and large areas of porous, blue-stained net-work on the edges. With higher power, a complete injection of the net-work was not visible, and a correct conception of the size and distribution of the pores was impossible, but the structure of the different filters varied greatly. The greatest irregularity was noted in the Berkefeld filter. Particles were found of about 100 micra diameter which outlined clefts 16 to 120 micra in diameter, but these clefts were not filled with brazoline. Therefore it is uncertain whether the brazoline either penetrated or passed through the clefts.

The deep staining of the sections of the Berkefeld filter evidenced by large blue blots of 20 to 100 micra in diameter, by low power appeared like an injected canal system, but with higher power no sharply outlined canals could be seen, the entire mass appearing as a woolly structure. With oil immersion it was impossible to perceive a net-work of fine canals. Probably we deal here with a fine substance impregnated with brazoline. He saw clefts much larger than the bacteria, and homogeneous masses in which no cleft could be perceived. Channels of one to two micra in diameter which would pass spirillum parvum and bacillus pyocyaneus were not to be seen.

In contrast to the Berkefeld filter mass, the Berlin porcelain plates of ordinary quality contain very few large crystalline masses and the granules are more equal—6 to 12 micra. The mass is stained unequally and a paler blue than the Berkefeld filter mass. By low power it appears like a net-work. By high power the blue patches show a woolly or spongy structure which is not completely resolved by the microscope.

In contrast, staining of the Chamberland filter, F, with brazoline methylviolet showed in addition to larger clefts filled with the brazoline numerous patches of a woolly appearance, which on oil immersion proved to be of spongy structure, the pores being about one-half micron or less in diameter. Channels of one to two micra in diameter were also seen. The Chamberland filter, F, would thus seem to be the most suitable for bacterial filtration.

On the basis of these investigations, Rosenthal concludes that the actual diameter of the pores of dense bacterial filters lies between one-half and two micra. He defines the actual pore size as the smallest diameter which can be found in at least one place among the innumerable channels. He explains that the passage of bacteria through dense bacterial filters is through the larger channels; the bacteria passing around the smaller clefts of direct communication between the two surfaces.

The time of filtration is probably too short, and the current hinders the passage of fluid through the larger pores.

FILTRATION TESTS OF ROSENTHAL

Rosenthal used plates of different makes and thicknesses instead of cylindrically shaped filters, and in these filtration tests experimented with the bacillus prodigiosus, the bacillus pyocyaneus, the bacillus erysipelatosus suum, and the smallest known visible bacteria —the spirillum parvum (Esmarch) and the invisible virus of fowl pest.

Tests on Berkefeld Filter Plates.—Five-millimetre-thick plates kept the test bacteria back. Once a 20-mm.-thick plate let the bacillus pyocyaneus pass. Up to 10 mm. the Berkefeld filter was regularly penetrated by spirillum parvum, and sometimes a 15- to 20-mm.-thick plate was not impervious. Cultures of spirillum parvum could be obtained from the filtrates, but the filtrates of fowl-pest virus were absolutely avirulent. Hence it was concluded that either the fowl-pest virus is not much smaller than the spirillum parvum or that the Berkefeld filter is not adapted for the comparison of these viruses.

Tests with Berlin Porcelain Plates.—Twelve-millimetre-thick plates sometimes retained the virus, at other times it passed through, but the filtrate was avirulent. According to these experiments, it is a question whether the condition of the filter bears any relation to the finest bacteria and to fowl-pest virus, or whether filters of the same quality and thickness do not differ by irregularities in their structure, as pointed out by Esmarch.

Tests on Chamberland Filter Plates.—Four Chamberland filter plates, No. F, 5 mm. thick, retained the spirillum parvum entirely. Three No. B, 3 mm. thick, were penetrated by spirillum parvum,

while of three No. B, 5 mm. thick, one retained the spirillum parvum and two allowed it to pass, and one of the same filters allowed the bacterium pyocyaneus to pass. With four filters, F, 20 mm. thick, only one virulent filtrate was obtained. With four 10-mm.-thick plates, small quantities of virulent filtrate were obtained from two.

With 10-mm.-thick plates, F, one ten-thousandth or, probably, only one hundred-thousandth of the fowl-pest virus passes through, and only one hundred-thousandth of it passes through a 20-mm.-thick plate. Spirillum parvum was retained two hundred times as often as the fowl-pest virus. Rosenthal concludes that the latter is different from spirillum parvum.

A porous filter which will absolutely retain the fowl-pest virus has not yet been found, but it is certain that one ten-thousandth part of the virus passes through.

Rosenthal thinks it might be possible to find colloidal solutions which would pass through the filter in the same quantity as the fowl-pest virus; then from the size of the colloidal particles we could estimate the size of the unknown micro-organism of the fowl pest; in other words, we would have the lower limit of their size, just as we know the spirillum parvum to be the upper limit.

These filtration tests of Rosenthal show that there is no equality in filters of the same brand and thickness, and that the common visible bacteria, such as the bacillus pyocyaneus, can pass through filter plates of such thickness as to be generally considered bacterially dense.

For comparative studies it is absolutely necessary to use filter plates of known brand and thickness, in form like the apparatus described by Rosenthal, instead of cylindrical filters, the majority of which are not uniformly constructed. All filtrations should be repeated several times, using a known visible and easily cultivable micro-organism; for example, bacillus pyocyaneus, bacillus prodigiosus, and the smallest known bacillus, the "spirillum parvum."

The discrepancy of many filtration experiments with unknown and, at present, invisible micro-organisms could be easily cleared up if all authors would give exact data concerning the kind and thickness of the filters used.

The question is, can we explain mechanically all the phenomena of filtration based on the theory that the porous filter consists

of innumerable sieves with openings of different sizes? According to Rosenthal, the actual pore size of the filter would be one-half to two micra. If the filter mass acts only in a mechanical way, it should be possible to filter other visible bacteria, for example, cocci, their average size being from one-half to two micra. The filtration of cocci through perfect filters has never been demonstrated. Therefore the filterability of a micro-organism does not depend merely on the pore size of the filter.

There must be physical relations (adsorption and surface attraction) between the micro-organisms and the filter substance, and probably the morphological structure plays an important rôle. This theory is supported by von Esmarch and Hoffstetter, who found that micro-organisms would not pass through clefts even though their diameter was larger than the micro-organisms.

Lode thinks that the filterable viruses are more pliant than the ordinary micro-organisms, and that they have a semisolid protoplasm which conforms in size to the pores of the filters.

Rosenthal, by using spirillum parvum as a visible micro-organism of known size and filterability with an unknown, invisible, highly filterable virus as fowl pest, showed that both viruses will pass the Berkefeld filter in almost equal quantity; but by using the Chamberland filter, F, the spirillum parvum is retained two hundred times more often than the fowl-pest virus. He concludes, therefore, that the fowl-pest virus must be smaller than the spirillum parvum. This is questionable, because we do not know to what extent absorption influences filtration. Another important factor is the dilution and, possibly, the motility of the virus and the spontaneous agglutination.

The highly virulent serous exudate of peripneumonia of cattle in an undiluted condition can be rendered avirulent by filtration, but in dilution of 1:10 with water or bouillon the filtrate is highly virulent. This may be explained by the presence of much albumin in the fluid. A fluid containing protein substances is hard to filter, the precipitate on the wall of the filter forming an impenetrable membrane. The formation by a protein substance of a colloidal membrane on the wall of the filter which will retain the smallest forms of the peripneumonia virus makes it certain that the same are larger than the protein molecule.

Why a micro-organism is filterable has never been satisfactorily explained. Whether the filterable viruses are more flexible, or whether there is less absorption owing to a different surface structure, or whether due to both conditions, remains to be decided. That a virus is invisible on account of its filterability is doubtful, as Rosenthal's experiments have shown.

Novy, Breinl and Kingshorn, and Borrel and Spiegel claim that certain developing stages of microscopically visible trypanosomes (*T. lewisi, T. brucei,* the spirochæte of European and African relapsing fever, and micromonas mesnili) are also filterable. Novy's experiments were not confirmed by Wolbach.

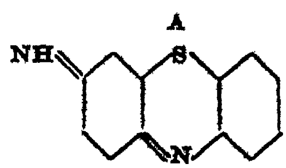
I believe that either the entire virus is visible or that certain developmental stages must lie within the microscopical visibility, and that we cannot see the filterable viruses is due to their special optical and tinctorial conditions.

STAINING PROPERTIES

The basic and acid aniline dyes as well as their neutral mixtures used for staining all known micro-organisms seem to have no affinity for staining the majority of filterable viruses. The spirillum parvum, the virus of peripneumonia of cattle, and of epithelioma contagiosum can be stained with the common bacterial stains (carbol-fuchsin, carbol-toluidin blue).

It is a question whether the minute cocci in molluscum contagiosum, in smallpox, and in variola vaccine are certain morphological forms of these viruses which are claimed to be made visible with Giemsa or carbol-fuchsin either with or without mordant.

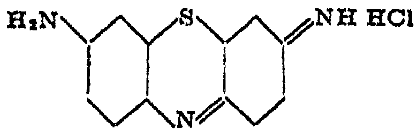
I have found that certain aniline dyes which belong to the group of thiazines,—methylenazur, methylenviolet, dimethylthionin, and toluidinazur,—in the form of their free bases will stain the virus of rabies, poliomyelitis, and smallpox. The simplest body of this group is the thiazine, and it alone is of theoretical value.



Imidothiodiphenylimid (Thiazine)

The amido derivative is the thionin.

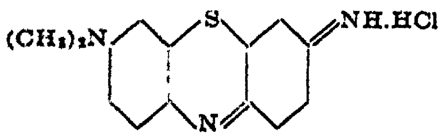
B



Thionin

By substituting two methyl groups (CH_3) for both H atoms, we obtain the dimethylthionin.

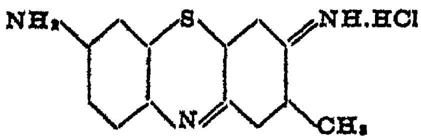
C



Dimethylthionin

If we substitute two methyl groups for both H atoms of one

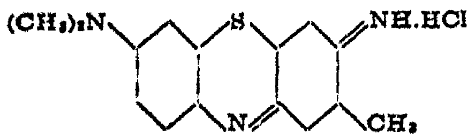
D



Toluthionin

amido group of the toluthionin, we obtain the dimethyltoluthionin or toluidinblue.

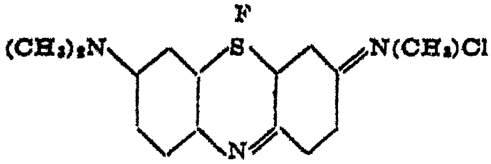
E



Dimethyltoluthionin (Toluidinblue)

If we substitute four methyl groups for four H atoms of both amido groups of the thionin chloride, we obtain tetramethylthionin chloride or methylenblue.

F

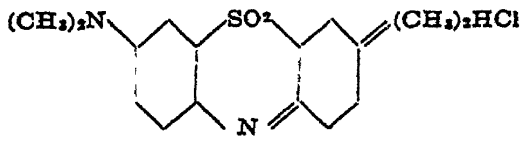


Methylenblue

By the action of alkali on methylenblue, two different products are obtained. According to Bernthsen, one part of the methylenblue

is oxidized in such a way that the S atom anchors two oxygen atoms and forms methylenazur. He gives it the following constitution:

G



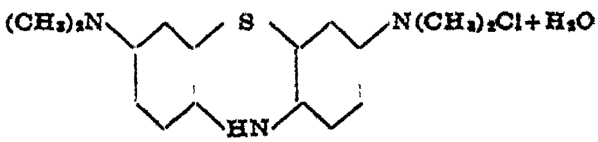
Methylenazur

Michaelis doubted this formula, and pointed out that the character of this body was more like thionin and toluidinblue.

In 1906 Kehrmann showed that methylenazur was a mixture of trimethylthionin and asymmetrical dimethylthionin, chiefly the latter. This was immediately confirmed by Bernthsen.

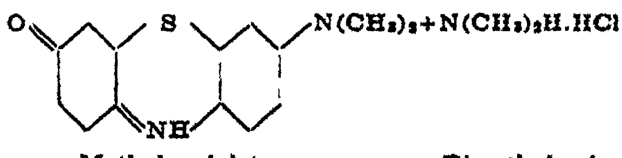
The other oxidation product is methylenviolet, which is formed by the splitting up of dimethylamin and anchoring one O atom.

H1



Methylenblue

H2



Methylenviolet Dimethylamin

A method for obtaining the methylenazur and methylenviolet from methylenblue is as follows: Dissolve the methylenblue in 1 per cent. sodium carbonate solution, and heat for one hour in a water-bath. Filter and evaporate on water-bath until dry. The residue is carefully dried and pulverized. The methylenazur can be extracted from the methylenviolet and unchanged methylenblue with ether.* The latter are insoluble in ether. After complete extraction of methylenazur with ether, the methylenviolet can be extracted with chloroform.

* A convenient apparatus for extraction is the Soxhlet fat extractor.

The toluidinazur,* the toluidinviolet, the æthylenazur, and æthylenviolet are not commercial. In their preparation I used the same method as is employed in making methylenazur and methylenviolet from the methylenblue. Neither toluidinblue nor æthylenblue will stain amyloid substance, but by oxidation new dyes are formed which do stain the amyloid. Toluidinazur, æthylenazur, and æthylenviolet stain amyloid substance a metachromatic red. The constitution of these new dyes remains to be analyzed.

The free bases of the above thiazine dyes can be precipitated with alkalies. They have the character of amine bases in contrast to the methylenblue base, which is chemically an ammonium base, whose free base is obtainable with silver oxide. The methylenblue base is soluble in water, giving the same color as the salt. The free bases of the thiazine dyes are of a reddish-brown color, and are readily soluble in ether and chloroform, giving a reddish color. I also find that they are soluble in neutral fats and the higher fatty acids, such as oleinic acid, stearinic acid, and lecithin.

On evaporation of the ethery solution,—for instance, the methylenazur base,—the red color changes to blue. This is believed to be due to the formation of carbonic acid salt by absorption of carbonic acid from the air. It is doubtful whether the free bases of the methylenviolet, dimethylthionin, etc., will form carbonates.

The free thiazine bases, with the exception of the methylenblue base, are analogous to other aniline dyes which have a tendency to polymerize and may exist in two tautomere forms. By tautomere we understand that a dye may exist in two different constitutions without changing its empirical formula, and that one form may change to the other, but it is impossible to isolate the molecule of one constitution from the other.

The existence of two tautomere forms, the red and blue modification, can be demonstrated in a watery solution of the thiazine dyes. For example, take a concentrated solution of methylenviolet or thionin. By dilution the violet color changes to pure blue. From this we may conclude that the blue methylenviolet is a dissociation

* Pappenheim mentioned that alkalized toluidinblue will stain sections like polychrommethylenblue. With chloroform he extracted a red dye from the alkalized toluidinblue solution which, as he thought, was the carbinol base of toluidinblue. He left undecided as to whether a toluidinazur exists.

product of the red methylenviolet, the blue methylenviolet polymerized to the red modification forming a larger molecule. According to this theory, the ether or chloroform solution contains the thiazine bases in a polymerized form which on evaporation will dissociate into the blue modification through the absorption of water. The blue color is not necessarily due to the formation of a carbonic acid salt, but is only the dissociated form of the red modification and is only stable in ether or chloroform.

That the reddish precipitate of the thiazine bases which is insoluble in a strong alkali solution is a polymerized form can be shown by shaking the precipitate with water. The watery solution will yield a red-violet color, and by weaker dilution pure blue.

That the blue dissociated form is not necessarily a carbonic acid salt is shown by dissolving the precipitate of the thiazine bases (for example, the methylenazur base) in freshly-boiled water saturated with hydrogen, when, in the absence of carbonic acid, the red modification will dissociate into the blue modification.

The watery solutions of the free thiazine bases are very unstable and easily polymerized and dissociated in contrast to their salts with inorganic acids. This may be demonstrated by shaking a watery solution of the methylenazur base and of the chloride with ether. From the watery solution of the methylenazur base the ether will extract the polymerized form, giving a reddish color. From the chloride no free base can be extracted. This is true of the other thiazine dyes.

The free methylenblue base and the thionin base will not stain the rabies, poliomyelitis, or variola virus. The reason for this, I believe, is that the methylen groups are an important factor in the tinctorial affinities. The unmethylized thionin and the completely methylized methylenblue are unable to stain the viruses, which can only be done by the partially methylized thiazine dyes, as methylenviolet, methylenazur, etc.

The difference between staining the common micro-organisms and the above viruses is that the former can be stained with the aniline dye salts of different aniline dye groups. The latter can only be stained with the free base of certain thiazine dyes.

Whether only the thiazine bases will stain these viruses or also the free bases of other aniline dye groups (triphenylmethan dyes,

oxazine dyes) remains to be investigated. My earlier experience with methylenviolet, with which rabies virus could be stained under unknown conditions, suggests that the free base of the triphenylmethan dyes may stain the virus.

Preparation of Solution for Staining.—So far the methylenazur has proven the most satisfactory. In commerce are different brands of methylenazur, any of which may be used (Gruebler, Ludwigshafen, Hoechst). They are obtained either in the form of the chloride or the carbonate. The carbonate is only obtainable from Gruebler, in Leipsic, and consists chiefly of the free methylenazur base. If the latter is used, 0.1 Gm. is dissolved in 10 Cc. of a 1 per cent. carbolic acid solution.

If the chloride is used, the free base is obtained by taking 0.1 Gm. and dissolving it in 10 Cc. of water with a few drops of concentrated sodium hydroxide added. The red-brown precipitate (free base) is centrifuged and the sediment dissolved in 10 Cc. of a 1 per cent. carbolic acid water. Staining solutions from the free bases of the chlorides of the other thiazine dyes may be made up in the same way. The solutions, if well corked and kept in the dark, may be used for two or three months. When they precipitate they are of no value for staining.

ETIOLOGY OF RABIES

Pasteur first demonstrated that the causative agent of rabies is found in pure organic culture in the central nervous system of hydrophobic animals. This formed the basis for all further investigations. Pasteur[6] tried to throw light on the etiology of this interesting disease. In fresh smears from the medulla oblongata of rabid animals he found many cocci-like formations, but he could come to no conclusion as to their significance. Similar formations were noted by Bouchard, Roux, and Gibier.

In 1896 Babes[7] demonstrated with the Cajal silver impregnation method and Giemsa many dustlike intraplasmatic granules of less than 0.1 μ diameter, which he thinks are a certain form of the rabies virus. To my knowledge, his investigations have not been confirmed by any other author; and, according to my belief, these granules are either pathological cell structures or silver precipitates.

An important discovery tending toward the solution of the etiology of rabies was made in 1903 by Negri.[8] With different staining methods he demonstrated peculiar bodies, especially in the large nerve-cells cornu ammonis of the brain. These cell inclusions are without doubt of great value in the diagnosis of rabies. They are found in about 90 per cent. of all the cases of street virus infection.

Negri thought these bodies to be a certain form of the rabies virus, which belongs to the protozoa. But they cannot be considered the causative agent of rabies for the following reasons: they are not found in every case of hydrophobic infection; they are not found in the salivary glands, and it is sure to discover them in the spinal cord.

The opinion of all noted investigators as to the significance of these bodies is that they are cellular reaction products which probably include the rabies virus or one of its forms. Whether the fine cocci formations found in the centre of the Negri bodies are a certain form of the rabies virus cannot be determined with the eosin methylenblue stain.

The latest work on the etiology of rabies is that of Koch and Rissling.[9] They demonstrated many cocci-like formations with the Heidenhain iron hæmatoxylin and Van Krogh stain. The differentiation of these formations from cellular degeneration products in pathologically changed brains is very difficult, and no conclusion can be drawn as to their significance.

Since the filterability of the rabies virus was demonstrated by Remlinger,[10] Di Vesta, Berteralli,[11] and Schueder, the general belief is that the rabies virus is invisible. According to Berteralli, the rabies virus is not entirely filterable through Berkefeld filter V, the filter remains being more virulent than the filtrate.

The filterability of the rabies virus could not be confirmed either by Stimson[12] or by myself, in spite of using the same filter. In my filtration experiments the brain substance was thoroughly emulsified, shaken for several hours, and diluted 1 ÷ 100. One-tenth of a cubic centimetre of the original dilution inoculated intracerebrally killed a rabbit in six or seven days.

Whether the positive filter results are due to defective filters or to other technical errors, I am unable to decide. However, the filtra-

Figs. 1–9.

1. Fixed virus, Pittsburgh. Bichloride alcohol, Gram-Much, oil immersion $\frac{1}{18}$, ocular 4.
2. Fixed virus, Pittsburgh. Bichloride alcohol, Gram-Löffler, oil immersion $\frac{1}{18}$, ocular 4.
3. Street virus I. Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.
4. Street virus II. Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.
5. Street virus III. Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.
6. Street virus IV. Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.
7. Salivary gland (dog). Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.
8. Human rabies. Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.
9. Gasserian ganglion (cow). Antiformin 15 per cent., Gram, oil immersion $\frac{1}{18}$, ocular 4.

Figs 10–14.

10. Salivary gland (dog). Antiformin 15 per cent, Gram, oil immersion $\frac{1}{12}$, ocular 4.
11. Salivary gland (cow). Antiformin 15 per cent., Gram, oil immersion $\frac{1}{12}$, ocular 4
12. Fixed virus, Paris. Original smear, methylenazurcarbonate, oil immersion $\frac{1}{12}$, ocular 4
13. Fixed virus, Chicago. Original smear, methylenazurcarbonate, oil immersion $\frac{1}{12}$, ocular 4
ote spirochæteform)
14. Fixed virus, New York. Original smear, methylenazurcarbonate, oil immersion $\frac{1}{12}$, ocular 4.

tion experiments should be carried out as designated by Rosenthal with plates of known thickness in order to reach a conclusion as to the filterability of the virus. The results of filtration experiments indicate, at least, that certain forms of rabies virus must lie within the microscopical visibility.

It is not definitely known whether the virus can be seen in a living state with the ordinary microscopical lens. The myriads of cellular elements which naturally are contained in the crushed brain substance make it almost impossible to differentiate them from the rabies virus. Whether their differentiation is possible by means of the microphotograph with ultraviolet rays has not been demonstrated.

The difficulty of demonstrating the virus in smears and sections must be due to special staining properties. With the usual basic and acid aniline dyes and their neutral combinations no micro-organism can be made visible. By use of mordants, for instance, carbolic acid aniline water in combination with basic aniline dyes, a few cocci or bacilli forms may sometimes be made visible.

On account of the rarity of such findings, it is difficult to decide whether such isolated formations are truly micro-organisms or some cellular elements.

In carrying out systematic staining experiments on fixed virus, using a vast number of basic aniline dyes, I found many cocci and bacilli in smears fixed in bichloride alcohol and stained with the Gram-Much method (Figs. 1 and 2), also with the modified Gram method after Löffler. But these methods were so extremely inconstant that the micro-organisms were found in only a few slides out of several hundred. These results show that these micro-organisms have no affinity for our common basic aniline dyes, and are only stained under unknown conditions. This discouraging feature led me to try another method. We know that the street virus is resistant to putrefaction, and this fact led me to consider whether it were not possible to dissolve the brain substance by a chemical agent, yet not destroy the virus.

For this purpose I used antiformin,[13] which is valuable in isolating tubercle bacilli and will dissolve organic structures and all known micro-organisms except acid-fast bacilli. The fresh or formalin fixed brains of rabid animals were dissolved in a 15

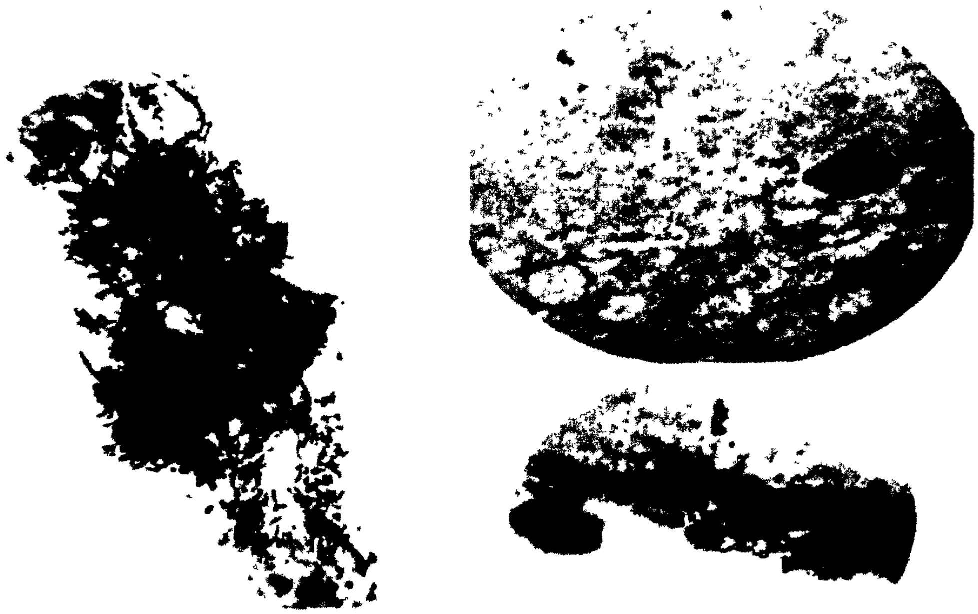
per cent. antiformin solution, and the sediment washed and stained after Gram. Cocci 0.3 μ in diameter and bacilli 1.5 to 3 μ thick were found, and were similar to those detected in smears previously made with a modified Gram stain. The same were also found in the salivary glands and nerve ganglions. (Figs. 3 to 11.)

The etiological relation of these micro-organisms to rabies was further proved by the production of typical rabies by the injection of rabbits with the antiformin sediment [14] of freshly-dissolved brains of rabid dogs. The virulence of street virus is destroyed in about ten minutes by contact with a 15 per cent. antiformin solution. The virulence of fixed virus is destroyed almost instantly by a 15 per cent. antiformin solution. The antiformin method has shown that a microscopically visible form of rabies virus exists, but it fails to demonstrate the micro-organisms in every strain of street virus, because all strains are not resistant to antiformin.

With methylenazur [15] I found a great number of micro-organisms in smears of fixed virus, seen in various forms, as follows: Merely visible small round cocci, either in pairs or groups, some stained light blue, and others stained metachromatic violet blue, their average diameter being approximately less than 0.2 μ; diplococci forms, 0.3 to 0.5 μ in diameter, some of them shaped like gonococci; short, thick, oval bacilli about 0.5 μ long; slender bacilli, straight or slightly bent, their ends thinner than the body, similar to the fusiform bacilli and 1.5 μ long, 0.1 μ thick; some thick, straight bacilli, with ends blunt, 2.5 to 3 μ long and 0.3 μ thick, and stained deep blue; isolated or clumps of bacilli, about 1.5 μ long and stained metachromatic; curved filaments, some with cocci form on one end or in the centre of the filament, and 2 to 3 μ long; slender bacilli about 3 μ long, ends slightly thinner than the body, some slightly bent, others decidedly curved, and some of these forms segmented; also straight, thick bacilli 2.5 to 4 μ long, ends either square or slightly rounded, homogeneous, and stained deep blue. A few pale blue spirochætes, 5 to 7 μ long, with wide turns, were found. (Figs. 12 to 17.)

The same micro-organisms were found in street virus, but were less numerous, and mostly in the form of thick bacilli. The pleomorphism of the micro-organisms is striking. The majority are cocci, short, thick bacilli, and long bacilli transmigrating into cocci. The spirochæte form was found in different strains of fixed virus.

FIGS 15-17.



17

15. Fixed virus, Chicago. Original smear, methylenazurcarbonate, oil immersion 1/12, ocular 4.
16. Fixed virus, Washington Original smear, methylenazurcarbonate, oil immersion 1/12, ocular 4. (Note spirochæteform.)
17. Fixed virus, Pittsburgh. Original smear, methylenazurcarbonate, oil immersion 1/12, ocular 4.

FIG. 18

Poliomyelitis virus, Flexner, smear spinal cord, methylenazur, ocular 4, oil immersion $\frac{1}{12}$. (Bacilli-form micro-organism.)

FIG. 19

Poliomyelitis virus, Flexner, smear spinal cord, ocular 4, oil immersion $\frac{1}{12}$. Methylenazur. Nerve-cell filled with micro-organisms

How can we interpret these various forms of the rabies virus? We know from clinical and experimental experience that the rabies virus travels along the nerve-fibres. A passive motion inside the nerve-cords is excluded, and we must accept the fact that there is a motile form of the rabies virus. The investigation of the life cyclus (spirochæte duttoni, spirochæte gallinarum) has shown that there is a dormant stage represented by a granular form which under favorable conditions develops into the motile form.

The cocci formations which I found in the salivary glands of rabid dogs probably represent the dormant stage, which is transmitted by the saliva to the wound, and under favorable conditions develops into spirochætes which travel along the nerve-fibres.

The curved filaments with cocci form on one end or in the centre probably represent the first involution stadium of the spirochæte form. The bacillary forms which possibly represent the vegetative stadium of the rabies virus seem also to develop from the cocci form.

ETIOLOGY OF POLIOMYELITIS

After Landsteiner and Popper [20] demonstrated that poliomyelitis can be transmitted to apes, and the same was confirmed by Flexner and Lewis [21] in America, Landsteiner and Levaditi [22] in France, Roemer [23] in Germany, Knoepfelmacher,[24] Leiner, and von Wiesner [25] in Austria, the experimental study of this disease became possible.

Apes are the only animals highly susceptible to poliomyelitis infection. All other lower animals, with the exception of the rabbit, are immune to the infection. Marks has transmitted poliomyelitis to rabbits after the successive passages of the virus through apes, but the transmission from rabbit to rabbit was unsuccessful, and the direct transmission of poliomyelitis from human beings to rabbits was impossible.

The virus seems to be chiefly located in the central nervous system; the blood and spinal fluid do not appear to be involved. At present, experience does not permit us to state whether it is distributed throughout other organs. In inoculated monkeys the virus seems to be invariably found in the central nervous system, less

frequently in the tonsil and nasopharyngeal mucus, in the mesenteric and other lymph-glands. It has not been found in the large internal organs of monkeys.

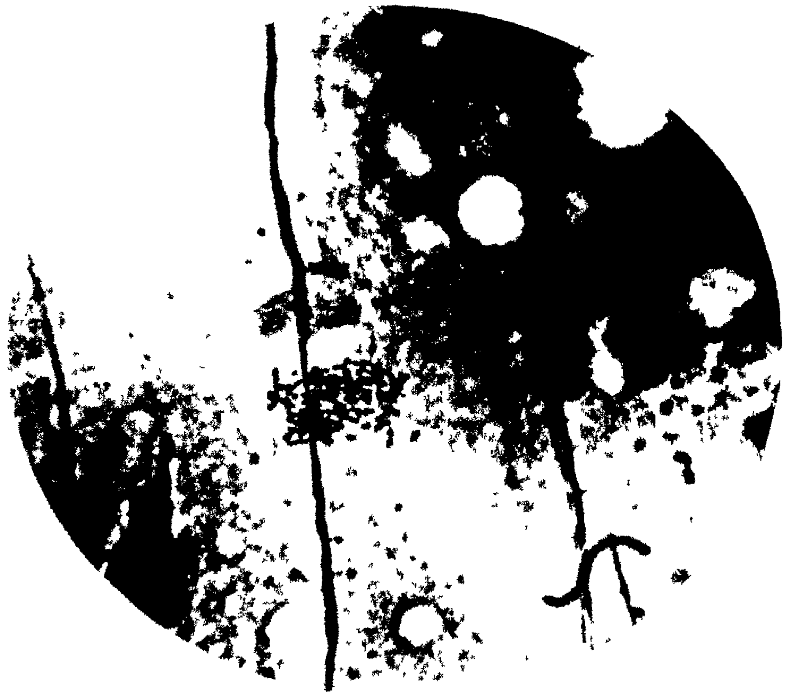
The virus is filterable (Landsteiner and Levaditi, Flexner and Lewis, Leiner and Wiesner). It penetrates the Berkefeld, Chamberland, Reichel, and Pukal filters. It can be preserved for several weeks in either pure or in 30 per cent. glycerine solution. Drying over sulphuric acid or sodium hydroxide, the virulence is retained for fourteen days. At room temperature and protected from light, it retains its virulence for four weeks. Its resistance to heat is slight, but its virulence is destroyed by heating for one half-hour at 45° to 50° C. Potassium permanganate 1: 1000 destroys it in one hour at 37° C.; one per cent. hydrogen peroxide, formaldehyde, and thymol in one hour.

No micro-organisms can be found with the common staining methods; those previously described are no doubt secondary infections.

The poliomyelitis virus, like rabies virus, produces an intracellular reaction product. Bonhoff described intracellular inclusions in glia and ganglionic cells, and I found intraplasmatic inclusions [26] in the ganglion-cells of the spinal cord of infected monkeys. By the Lentz method these inclusions stained a homogeneous carmine red, and were more widely distributed than in rabies. Flexner and Lewis attempted the cultivation of the virus by inoculating serum bouillon with the filtrate of spinal-cord emulsion. By incubation the bouillon was cloudy, and by inoculation in fresh bouillon the cloudiness was observed only twice, but it is a question whether these were true cultures. Levaditi found oval or round pairs or groups of very small bodies in such cultures with Löffler's flagellæ stain, with Giemsa solution, and with prolonged staining with fuchsin.

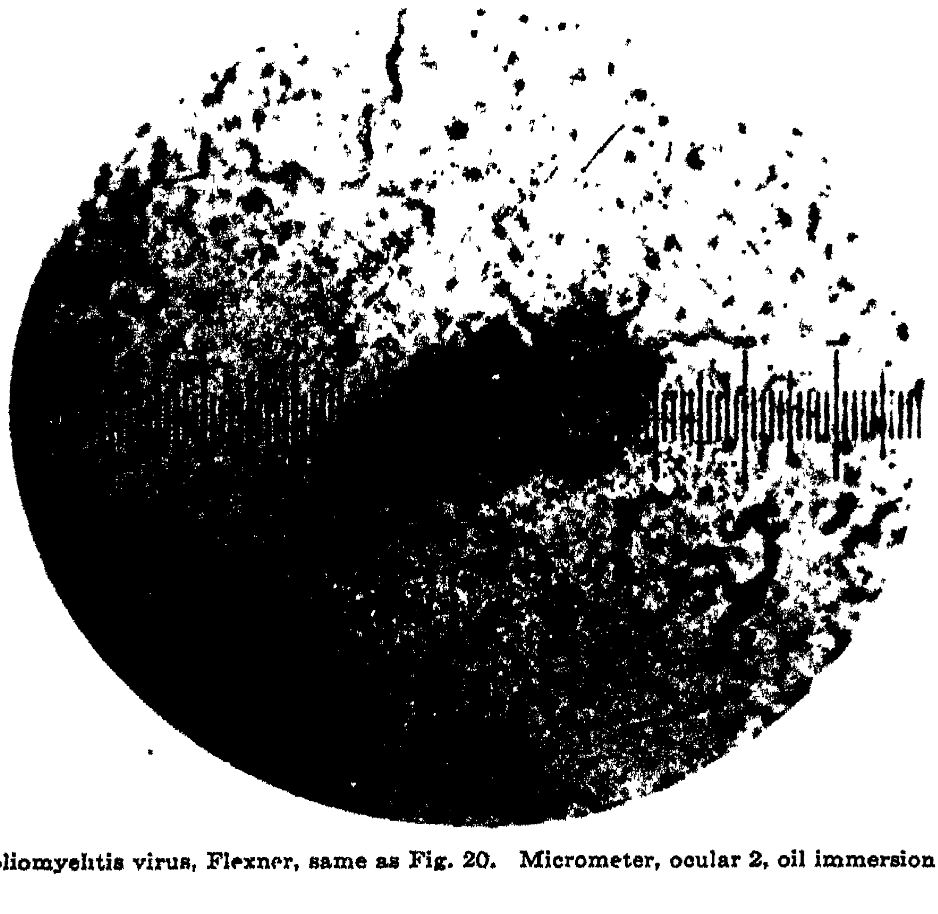
The minuteness and the indefinite morphological structure of these bodies make it impossible to determine whether they were micro-organisms or stained protein precipitates; I believe they were the latter. Recently, Flexner and Noguchi [27] resumed their efforts toward cultivation of the poliomyelitis virus. Under anaërobic conditions, and using ascitic agar or brain extract to which fragments of sterile kidney of a rabbit were added, no growth was perceptible

Fig 20



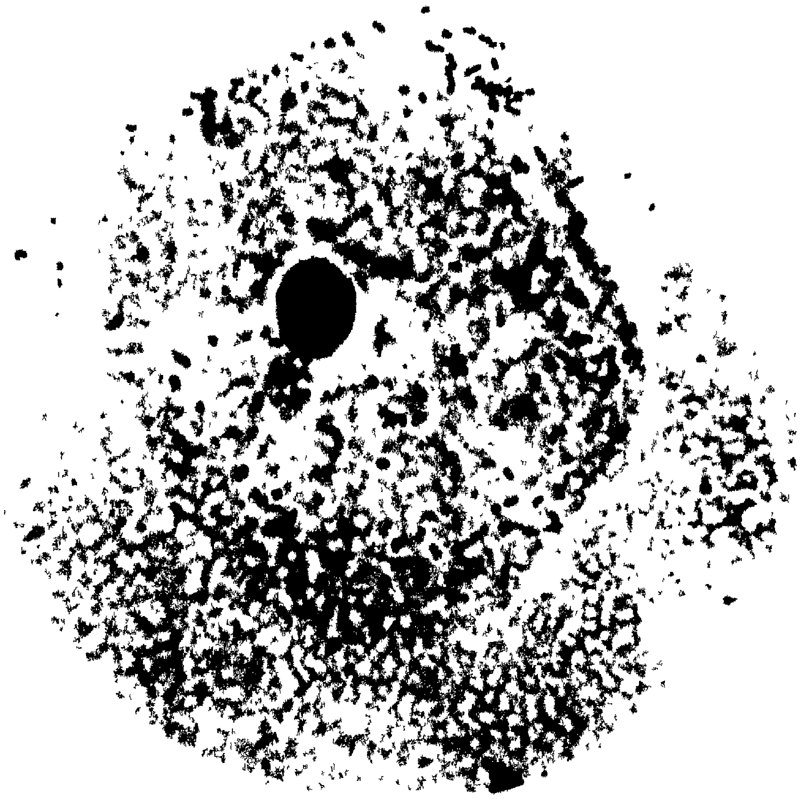
Poliomyelitis virus, Flexner, smear from brain, ocular 4, oil immersion $\frac{1}{12}$ Cocci and bacilliforms

Fig 21



Poliomyelitis virus, Flexner, same as Fig. 20. Micrometer, ocular 2, oil immersion $\frac{1}{12}$.

Fig 22.

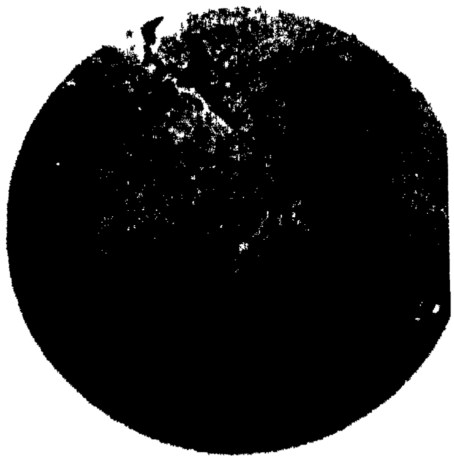


Smear from contents of variola pustule. Methylenazur, ocular 4, oil immersion $\frac{1}{12}$. Epithelial cell filled with micro-organisms

Fig. 23.

Smear from contents of variola pustule. Methylenazur, ocular 4, oil immersion $\frac{1}{12}$. Intranuclear micro-organisms.

Fig 24.



Poliomyelitis virus, Flexner, smear spin cord, ocular 4, oil immersion $\frac{1}{12}$. Methy lenazur, spirochæteform.

in the first medium, but in the second, after several days' incubation, minute colonies were seen clouding the culture medium.

Microscopically, the colonies consist of globular or globoid bodies, in size 0.15 to 0.3 micron, and arranged singly, doubly, in short chains, or in groups. The micro-organisms which stained reddish-violet appear to be identical with bodies demonstrated by Noguchi in sections from nervous tissue. The third culture obtained from human strain and the fifth culture from monkey tissue caused in monkeys typical poliomyelitis. They leave undecided the question whether these are true cultures or only diluted virus, carried over accidentally and producing the disease.

With methylenazur * I found in smears from the central nervous system of monkeys infected with poliomyelitis † the following micro-organisms: Extremely small cocci stained pale blue, deep blue, or metachromatic violet. These were on the limit of visibility (0.1 micron), appearing singly or in chains or groups. Deep-blue diplococci shaped like gonococci, approximately 0.2 micron in diameter; short, thick, oval bacilli about 0.1 micron long and in the form of diplobacilli, and single ones 1 to 2 micra long, stained deep blue; slender bacilli about 2 micra long, stained pale blue; a spirochæte form 3 to 5 micra long, slightly curved and stained pale blue. The bacilli were the predominating form. The virus is extracellular, intraplasmic, and intranuclear in location. (Figs. 18 to 21.)

The spirochæte indicates that the virus travels actively within the nerve-fibres like the rabies virus, as was illustrated by the injection of the virus into the large peripheral nerve-trunks. This may be true of the natural infection mode also,—that the virus travels actively through the olfactory nerve into the central nervous system instead of being passively carried through the lymph stream.

VARIOLA

Etiology.—We can safely say that none of the many micro-organisms which have been described, including those studied by

* I had previously demonstrated many small cocci in an otherwise sterile central nervous system in a case of human poliomyelitis.

† To Prof. Simon Flexner I am indebted for the poliomyelitis virus from monkeys for experimental purposes.

Prowazek, can be accepted as the causative micro-organism of variola.

Since the filterability of variola virus was demonstrated by Negri [16] in 1905, all commonly known micro-organisms have been excluded as its etiological factor.

Variola is a difficult virus to filter. It will pass only through Berkefeld filter V. The material must be thoroughly emulsified, diluted 1 to 10 or 12 with distilled water, well shaken, passed through a lymph mill, filtered through several layers of sterile cotton, then through filter paper, and finally through a Berkefeld filter V. Filtrates obtained by Negri in such manner gave typical changes by inoculation into the cornea of a rabbit, and typical pustules by inoculation into the skin of a child and of a calf. Positive results from the filtrate can be obtained only by thoroughly rubbing it into the scarified skin and cornea.

Negri's filter experiments were confirmed by Remlinger and Nouri, Vincent, M. Nicolle, Abid Bey, Carini, and Levi Della Vida.

In 1906 Casagrandi claimed that the virus can not only be filtered through Berkefeld filters N and V, but also through the common Berkefeld filter and Berkefeld filter W, as well as through the Silberschmidt, Chamberland F, and Kitasato B. He also demonstrated the filterability of the vaccine virus.

Prowazek and Beaurepaire,[17] after filtration through Berkefeld filters, concentrated the virus in colloid materials, such as agar.

Siegel was the first to examine microscopically the Chamberland filtrates from the organs and blood of a rabbit infected with variola vaccine. He described motile formations, 0.5 to 1 micron long, oval on one end, pointed at the other.

Muehlens and Hartmann, Zuepfle and Prowazek found the same in the blood of non-vaccinated rabbits, and believe this formation to be only a degenerative product of normal blood.

Paschen found many small round bodies in smears stained with Giemsa from the pustule contents of vaccinated children. Some of these bodies were divided, but connected by a fine filament; others showed a visible flagella-like filament. With the Volpino-Levaditi method he found the same in pustules from a calf and from an inoculated cornea. With Löffler's flagella mordant and aniline fuchsin he found similar bodies one-fourth micron long.

In 1907 Volpino found with a dark-field illuminator round,

slightly refractible movable bodies, which were mostly intracellular, in the inoculated cornea. These appeared only in the vaccine and could not be stained with either hæmatoxylin or Giemsa. In smears he could not differentiate them from precipitates, etc.

Prowazek thinks that the initial bodies which he described in 1905 as round and oval bodies found in the protoplasm of the epithelial cells in small alveoli are a certain developing stage of the variola virus.

The Guarnieri bodies, according to Hueckel and Prowazek, are not the causative micro-organism, but a hyperproduction of nuclein bodies. These initial bodies were seen later by Paschen, Muehlens, and Hartmann.

During a smallpox epidemic in Rio de Janeiro, Prowazek and Beaurepaire found with the colloidal filter method and staining with Löffler's carbol-fuchsin, Giemsa, and thionin, round red formations which were smaller than the smallest known bacteria; unstained, they appeared as very minute, light-refracting bodies. Agglutination with vaccine serum was negative. However, the minute size of these bodies makes it almost impossible to differentiate them from precipitates and to determine their significance.

The smallpox epidemic in Pittsburgh, in September, 1912, gave me the opportunity to examine the pustular contents from thirty cases. The material was taken with sterile glass capillaries in the first few days after the appearance of the pustules, and examined fresh with a dark-field illuminator, as well as smears stained by different methods. Only the pustule contents which had proved to be sterile on all of our common culture media were used for investigation. The number of these was twenty.

With the dark-field illuminator no definite conclusion could be arrived at as to the presence of micro-organisms on account of the cellular débris. With common staining methods no micro-organism of any form was visible. Smears made from contents diluted 10 to 12 times, mordant with Löffler's flagella mordant and stained with carbol-fuchsin, Giemsa, and thionin showed no micro-organisms whatever. The minute bodies described by Paschen and Prowazek were seen, but I believe these are not micro-organisms, but some artefacts produced by fixation of the protein matter contained in the pustular contents.

By staining the air-dried smears fixed in methylalcohol with methylenazurcarbonate I found a great many micro-organisms, their size ranging from less than 0.2 to 1 micron. (Figs. 22, 23, and 24.)

There were isolated or diplobacilli, chains or groups of short, oval bacilli, very small, diplococci-like pneumococci, and bean-shaped diplococci, all divided by a small, pale-stained zone; also large, round cocci, sometimes divided into four parts like tetragenus. The majority of these micro-organisms were intracellularly located and quite often inside the nucleus. Some of the epithelial cells were entirely filled with these micro-organisms. Extracellular, they were few in number.

The same micro-organisms could be found in different strains of glycerinated vaccine. The vaccine was diluted with distilled water, centrifuged, smears made from the sediment, and stained in the same way as the variola. After filtration of greatly diluted vaccine through Berkefeld filter V, and centrifuging the same, I found the same micro-organism in the filtrate. In sections from vaccine keratitis and vaccine pustules from monkeys similar micro-organisms were found, but they were few in number.

SUMMARY

My tinctorial studies on the etiology of smallpox, poliomyelitis, and rabies have demonstrated that these micro-organisms which are more or less filterable and classified as ultramicroscopical or invisible viruses can be made visible with certain dyes belonging to one and the same group of aniline dyes, and that filterability should not be confounded with microscopical invisibility. The term ultramicroscopical or invisible virus should be discarded.

We have seen that the actual pore size of porous filters of whatever make is about 0.2 micron. The smallest forms of rabies, poliomyelitis, and smallpox virus are less than 0.2 micron in length.

The poliomyelitis virus is the easiest to filter. It passes through the Berkefeld, Chamberland, and Pukal filters with the same ease, while the rabies and variola virus will pass only the Berkefeld filter V, and then only by thorough emulsification of the material. The filtration of the two latter viruses could not be confirmed by any investigators, in spite of using the same filter and technic.

The cause of the many failures in filtration cannot be definitely ascertained, but it seems that not the filter alone nor the intracellular location of the virus is responsible. The chief reason seems to be that the peculiar structure of the micro-organisms, not their size, allows them to pass through the pores of the filter.

The invisibility of these micro-organisms while alive must be due to high light refraction. For instance, in spite of the infectiousness of the otherwise sterile contents of variola pustules, no micro-organisms can be seen with our ordinary microscopes and highest magnification and slant illumination.

The content of the variola pustule is most favorable for direct observation on account of the small amount of its cellular detritus, which allows us, *per analogiam,* to conclude that other filterable viruses in a living condition are also highly refractible and invisible with our common methods. The cellular detritus in the virus of rabies and poliomyelitis hinders the direct observation of the micro-organisms.

Filterable viruses are distinguished from other common micro-organisms by the fotmation of more or less specific cellular inclusion products. These inclusions, which have a peculiar location in each disease and more or less specific staining properties, were once considered to be a certain developing stage of the virus, but are now regarded as cellular reaction products formed by the virus from the cellular contents. No other known micro-organisms produce such cellular reaction products,* even by parasitismus in lower vertebrates.

Prowazek [28] designated the filterable viruses † as "chlamydozoa," which means micro-organisms which lead to the formation of peculiar reaction products in which they are isolated and included.

According to Prowazek, the chlamydozoa are more nearly related to protozoa than to bacteria. They are cell parasites, the cells responding to the invasion of the virus by a production of characteristic reaction products which, as a rule, have an affinity for

* The intracellular location of the lepra bacilli is probably phagocytic.

† Variola, vaccine, scarlatina, rabies, chicken pest, trachoma, molluscum contagiosum, epithelioma of birds, carppox, the lip disease of barbel, icterus of silkworm, possibly the dog distemper, foot-and-mouth disease, and the borna disease of horses.

nuclei stains. He asserts that the virus chiefly attacks the cells of the host and locates there with a hyperproduction of morphologically different substances, possibly derived from chromatin substances.

The cellular reaction products in trachoma, vaccine, epithelioma, and some cases of carppox are nearly related to the nuclear substances. They stain bluish or blue-violet with eosin azur, and black with iron-hæmatoxylin (Haidenheim).

The vaccine reaction products stain with methylgreen acetic acid similar to nuclei substances. They are resistant to trypsin and pepsin, and are deformed and finally dissolved by a 20 per cent. sodium chloride solution, a 40 per cent. potassium carbonate solution, and by diluted sodium hydroxide. The osmic acid reaction and the Berliner blue method are negative.

The cellular reaction products found in hydrophobia and fowl pest are probably derived from the nuclei. Those in fowl pest stain red with triacid, red with eosin, red to violet with the Mann method, and violet with pyronin methylgreen. In the brain of fowls killed two days after infection Prowazek found one or two large, oval, pink-stained formations which sometimes contained one or two deeply-stained dumb-bell formations.

In molluscum contagiosum the cellular reaction products are formed from protoplasm and fuse together, forming a net-work which stains deep blue with methylenblue. Iodine gives a brown color. Fat and amyloid reactions are negative. In icterus of silkworms the inclusions are of a biocrystalline nature, probably of protein origin. In dog distemper peculiar cellular reactions were found by Lentz; in foot-and-mouth disease by Siegel. The reaction products, according to their location, appearance, and tinctorial affinity, are specific for each disease. These inclusions are called Guarnieri bodies in vaccine and variola; Negri bodies in rabies; Mallory's cyclasterium in scarlet fever; Bolles polyhedric bodies in icterus of silkworms, and molluscum bodies in molluscum contagiosum. No special name is given in epithelioma of birds, chicken pest, and cowpox.

The reaction products are located in cells of the ectoderm,—in the epithelial cells in vaccine, scarlatina, molluscum contagiosum, trachoma, and epithelioma of birds; in the nerve-cells in rabies, chicken pest, and dog distemper; Bolles polyhedric bodies in fat

tissue, peritracheal tissue, salivary gland, oviduct, and the muscle layer of the ovary in icterus of the silkworm.

Loewenthal found the specific reaction products in the nuclei of the cells in cowpox, but outside the nuclei in epithelioma of birds, trachoma, and molluscum contagiosum. According to Schiffmann, they were extracellular in chicken pest, and to Prowazek, in the connective tissue in scarlet fever.

In spite of their constancy, these reaction products cannot be the causative agent in these diseases. After the destruction of the Guarnieri bodies in vaccine with 20 per cent. sodium hydroxide, a positive inoculation can be made. Also in vaccine and icterus of the silkworm positive inoculations can be made from diluted material 1:1000 in which microscopically no form elements can be detected. Negri bodies are not always found in full virulent material, as is proved by inoculation.

The appearance and structure of these bodies speak against their protozoic nature. They have no protoplasm structure. They are hyaline, and the changes which are interpreted as developing cyclus are only degenerative processes.

V. Schilling[29] has pointed out how careful we must be in the interpretation of the chlamydozoa as micro-organisms. He showed that under certain conditions in normal and pathologically changed red blood-cells structures can be made visible which are almost identical with parasites. He demonstrated that these structures found in the Guarnieri bodies are similar to those found in the vaccinated rabbit cornea. These pseudoparasitic structures probably originate from the archoplasma, or they may be of karyogen origin. They are not simple degeneration products nor fluid nuclei derivatives, but apparently living and growing structures.

He believes that we here deal with invisible or early premodial cell structures, especially of the archoplasma, which under pathological conditions develop into forms which are easily made visible, as we see this physiologically for special cell varieties. Therefore, every foreign inclusion in metazoa cells need not necessarily be the direct product of parasites.

That the granules found within the inclusions of the chlamydozoal diseases are the causative micro-organisms seems questionable, since we see such granules in toxic degenerated erythrocytes.

To differentiate the chlamydozoa which appear in the form of cocci or diplococci from cellular granulations is almost impossible, and the conclusion of Lindner that the cellular inclusions found in these diseases are caused only by ultravisible virus must be ignored.

My investigation has confirmed Prowazek's prediction that the viruses which form intracellular inclusions must be intracellularly located. I find that the virus of rabies, poliomyelitis, and smallpox is both intraplasmic and intranuclearly located. The formation of the intracellular inclusions is due to the action of the micro-organisms or their toxic products.

Certain conclusions may be drawn from the staining properties of these micro-organisms as to the chemical composition of the protoplasmic substance. The facts that the thiazine dyes are soluble in neutral fats and higher fatty acids, that the micro-organisms are stained either metachromatic or the same color as the polymerized base, that they are only stainable with the watery solution of the free base which must be anchored by a lipoid substance in which the polymerized base is only stable, suggests that the protoplasmic substance must be a peculiar lipoid protein. The chemical nature of this lipoid substance cannot be determined until we have a pure culture of these micro-organisms. But the lipoid nature satisfactorily explains the peculiarities of these viruses. The lipoid substance lessens the cohesion and gives a greater plasticity which allow the micro-organism to conform to the pores of the filters. It explains their invisibility in a fresh condition, the lipoid substance having high light-refracting properties. It explains their resistance to drying and freezing, and the preservation of the virulence by the action of glycerine. They may be designated azurophile or thiazineophile micro-organisms because of their peculiar staining properties.

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THE DIAGNOSIS OF EXTENSIVE PULMONARY TUBERCULOSIS IN OBSCURE CASES

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THE diagnosis of the extent of the tuberculous process in the lungs is of the utmost importance in those cases where the lesions, though disseminated through considerable lung tissue, produce physical signs that vary only slightly from the normal, and which by themselves indicate no single pathological condition, and also in cases revealing no signs that are definitely abnormal. While in some of these cases it may be impossible to detect any irregularities in the physical signs, the diagnosis being made tentatively on account of the severity of the symptoms, the majority will reveal some departure from the normal, even if very slight, provided it is carefully looked for by the trained observer. Thanks to the postmortem room and the X-ray, the significance of these slight signs has been indisputably demonstrated.

The subject is important for the very practical reason that the extent of the lesion should be one of the main elements in directing our treatment. Too much reliance has often been placed on constitutional symptoms alone, especially when the more extensive abnormalities in the physical findings are slight in degree. The wisdom of this view is supported on theoretical grounds, for the larger the number of tuberculous foci the greater chance is there, other things being equal, for the disease to spread, and theory in this instance is entirely upheld by practical experience. Longer periods for cure, more constant watchfulness, and more careful directions after arrest of the disease are required in many of these cases than in those with incipient apical lesions.

While the literature in recent years on the diagnosis of slight lesions limited to the apices has been most prolific, much less has appeared on slight lesions scattered over a large area. Descriptions

of various conditions encountered in advanced cases, such as cavities and fibroid disease, have been carefully elaborated, but little special attention has been directed to the class of cases under discussion. There is one striking exception to this, namely, the excellent work that has been accomplished through the X-ray in clearing up some of these obscure cases, of which a good example is to be found in an article by Jordan (A. C. Jordan, "Peribronchial Phthisis," *The Practitioner,* 1912, lxxxviii, 248). My interest in the matter was particularly stimulated because of the paucity of literature on this subject, my own first clear conception of how extensive and how great lesions could occur with only slight or even no abnormal physical signs being formed by comparing the clinical signs with revelations at autopsy and on X-ray plates. As with the literature so has it been with the diagnostic ability of the average physician. While to-day he more frequently diagnoses early apical disease, and often suspects it when he cannot elicit corroborative physical signs, he is much less prepared to make an approximate estimate of the extent and character of the lesions in advanced cases, and to realize the significance of extensive though slight changes in the physical signs, changes which, if limited to an apex, would immediately arouse his suspicion of an infiltrative process.

I shall refer very briefly to the history and symptoms of the type of cases under consideration, a little more fully to the physical signs, only slightly to the differentiation of these from other conditions, and shall conclude with a short summary of a few illustrative cases. While a number of the cases have been examined with the X-ray, the deductions are based largely on records at the Henry Phipps Institute, especially those dealing with cases under my personal observation. At this Institute hundreds of cases have been studied clinically, and later at autopsy, the clinical records of many of them having been made at frequent intervals before death, and in some instances by several different physicians, there being presented in this way a collection of comparative records that, so far as tuberculosis is concerned, is unique.

To enter at all exhaustively into the diagnosis of advanced pulmonary lesions of any sort would be far beyond the scope of this

paper. The remarks shall be confined to such considerations as seem most indicated in a brief discussion of this subject.

The History and Symptoms.—As in the diagnosis of incipient tuberculosis, the history and symptoms may justify a diagnosis of extensive pulmonary lesions even in the absence of corroborative physical findings. When the history and symptoms are those ordinarily associated with widespread involvement this condition should always be suspected even if physical examination furnishes no confirmatory evidences. While it is true that marked constitutional symptoms may be present with small localized lesions, yet the proportion of such cases so classified decreases with larger experience and with greater expertness in eliciting and interpreting physical findings.

A continuance of severe constitutional symptoms for any considerable period of time, or even the persistence of relatively mild symptoms in spite of proper treatment, more especially if they manifest any tendency to become aggravated, should always lead one to renew his search for extensive variations in the physical signs. If with the patient in bed for some weeks or months the fever fails to subside, or the pulse-rate to fall to the normal level, or if the weight record remains unchanged, the possibility of greater pulmonary involvement than was at first diagnosed is always to be borne in mind. A marked degree of severity of the symptoms, such as a great loss in weight, a very rapid pulse, or a marked dyspnœa, should direct suspicion to lesions beyond the incipient stage. Rapid development of the symptoms should make one search with particular care for these larger lesions. Many other important factors of a general sort could be discussed if sufficient space were available. As a matter of fact, whatever in the history or symptoms suggests a doubtful or unfavorable prognosis may possibly depend on greater pulmonary involvement than is revealed by the signs in the chest.

Among the symptoms dyspnœa in particular is sometimes to be regarded as a most suspicious evidence of extensive lesions when the physical signs fail to be of value. Often imperceptible to the patient or being only slight in degree until the disease has made manifest progress, it adds, in a certain number of cases, great weight to a diagnosis of extensive lesions that are quite obscure. Being notor-

iously a mild symptom even in many advanced cases, its appearance to any marked degree, or its long continuance, even if slight, though the case seems a light one in other respects, should always arouse suspicion of considerable involvement. In one case (Case No. 8) the patient first became dyspnœic about one year before the cough developed. Two months after the appearance of the cough the patient was seen for the first time, being then quite dyspnœic, though the only abnormal physical signs were râles at the right base. The patient died ten months later, the changes in the physical signs being of very slow development. Another patient (Case No. 1, Fig. 1) was under constant observation for a year, the only positive evidences of an extensive lesion being revealed by the X-ray, approximately the same changes being found at the beginning and close of this time. Throughout this period he would become markedly dyspnœic on the slightest exertion, though his temperature would always remain normal and his pulse usually so.

Physical Signs.—When, in tuberculosis, abnormal signs are found only at some portion of the chest where ordinarily the disease does not make its start, it is always well at least to suspect that these commoner sites for the beginning of the disease are simultaneously involved, even if this cannot be definitely proved. Thus, in cases that present the earliest abnormal signs at one base the probability is that some other portion, either an apex or the root of the lung, is also affected. (Case No. 8.)

All the abnormal variations in the physical signs found in incipient apical tuberculosis may be met with in extensive lesions, the only difference being that in the latter case they are more widespread. This fact is at times not appreciated, cases frequently being encountered in which signs that would have been interpreted as signifying pulmonary involvement if found at an apex, when presenting over a large area of the chest elsewhere than at an apex, are attributed simply to a thickening of the pleura without suspicion of pulmonary infiltration.

In extensive pulmonary disease abnormal physical signs may be entirely absent, or they may be very slight, so that if they are considered disassociated from the history and symptoms they may suggest only the slightest degree of pulmonary involvement. Overdiagnosis is also a possibility in the presence of elusive physical signs, as is

well illustrated by a case (Case No. 9) in which quite extensive tuberculosis of the right lung was diagnosed, all the signs being due to obliteration of the pleural cavity by slight adhesions without appreciable thickening, the lung perhaps suffering from slight passive congestion.

Various factors may combine to make a diagnosis of extensive lesions difficult. These may pertain to the character of the disease, or to peculiarities in the patient. If the individual lesions are small, although scattered over a wide area, they may change the physical signs to only a very slight extent, the same being sometimes true after they reach considerable size. Centrally-situated lesions, of which a common example is the type that starts its development from the root of the lung, may readily escape detection until considerable tissue has been destroyed. Added difficulties are encountered in trying to determine the character of a lesion on the sounder of the two sides after compensatory emphysema has been established, the opposite side being nearly or totally functionless. It is surprising how small an amount of lung tissue, especially if it is hyperfunctionating, is required to obscure a lesion when it margins or overlies it. Bilateral and symmetrical lesions are less readily disclosed than unilateral or decidedly asymmetrical ones. Among individual peculiarities that are especially confusing are very poor general expansion and very weak breath sounds, which will seriously interfere with eliciting unilateral variations in the expansion and breath sounds, signs which in many cases are among our chief supports in making a diagnosis of extensive involvement.

Curving of the Nails and Clubbing of the Fingers.—Curving of the nails and enlargement of the finger ends, to mention a single condition in the physical examination apart from the chest, should always make one suspect more than incipient tuberculosis, because this finding is so much more frequent late than early in the disease. Rarely occurring without demonstrable cause, it marks, as a rule, if at all pronounced, considerable progress in a case of tuberculosis. A typical example is Case No. 2, in which extensive lesions could only be suspected on physical examination though revealed by the X-rays, but in which there was marked bulbous enlargement of the ends of the fingers.

Of the various procedures in the routine examination of the chest none should receive closer attention than inspection. To avoid mistakes and to secure the best results a good light should fall on the patient with equal distribution on the two sides of the chest. Flattening or any decrease in size on one side of the chest is a very valuable sign if obtainable. More delicate changes are usually to be elicited on studying expansion. For this a good light is essential; in fact, it is rather the exception for a sufficiently good light to be obtainable, and recourse must be had to palpation. During this procedure the physician should stand directly behind the patient with his hands placed symmetrically on either side of the patient's chest. Retardation of motion as well as limitation of motion is to be sought for. Where there is extensive disease expansion may be unequal when other changes in the physical signs are very slight or even altogether absent. (Case No. 2, Fig. 2.)

Palpation.—In cases in which the existence of an extensive lesion is doubtful, my experience has been that vocal fremitus adds nothing to the information to be derived from other sources. Localized tenderness may be due to pleurisy, which in turn may be associated with a pulmonary lesion, even if the physical signs do not support this suspicion.

Percussion.—As with incipient apical lesions so with widely-scattered early infiltration, percussion does not usually reveal the first changes in physical signs. A slight degree of hyperresonance, a slightly higher pitched and shorter note, or even a little impairment, are to be looked for. Any distinct impairment always suggests that the individual areas of infiltration are of considerable size or are quite close together. At autopsy one is often surprised to find out how much pulmonary involvement may be associated with a comparatively resonant percussion note. (See Cases Nos. 1, 2, 3, 4, 5, 6.)

Auscultation: The Breath Sounds.—The breath sounds frequently furnish us with the earliest changes in the physical signs,—in extensive lesions just as they do in early apical involvement. This applies to both acute and chronic pulmonary conditions. The order of frequency w
occur in incipi
opinions:

Minor	Turban	Grancher
1. Rude or granular breathing, chiefly inspiratory.	1. Rough vesicular.	1. Feeble.
2. Feeble breathing.	2. Weak vesicular.	2. Rude.
3. Cog-wheel breathing.	3. One and two mixed.	3. Cog-wheel.
4. Harsh vesicular breathing.		4. Bronchovesicular.
5. Vesiculobronchial or bronchovesicular breathing.		

Of these variations in the breath sounds the one that has proved most serviceable to me, so far as early extensive lesions are concerned, is a diminution in the respiratory murmur. This decrease may be so slight as to be only appreciable by a most careful comparison of symmetrical regions on the two sides. In eliciting so delicate a sign the relatively weaker breathing that occurs normally at the right base posteriorly is to be borne in mind, this being found in 67 per cent. of Cabot's 250 cases. Normal quiet breathing as well as forced respiration is to be tested for abnormalities in the breath sounds.

Râles.—Râles occurring over extensive areas of the chest are to be sought for with as much care and to be given as much significance in suspected extensive lesions as in early apical lesions. Crackling, crepitant, and even sibilant râles when localized should always arouse the suspicion of pulmonary infiltration, even if other physical signs do not establish this diagnosis. As Austin Flint said a half-century ago, bronchitis, when circumscribed, is incidental to some other pulmonary disease. No adventitious sounds can be classed as in any sense pathognomonic of pleural inflammation except typical leathery friction rubs. The methods for eliciting râles, such as having the patient cough or change his position or report for examination on different occasions, are commonly employed for suspected apical lesions, and should be tested quite as reasonably over other parts of the chest when advanced conditions are suggested.

Vocal Resonance.—The vocal resonance may be of slightly more assistance in early extensive lesions than the vocal fremitus, but rarely adds much to our information. Slight changes in quality and pitch are to be looked for as well as in intensity.

Diagnosis.—As has been said, many of the signs referred to are in no way distinctive of extensive pulmonary involvement. The

diagnosis in tuberculous cases usually rests between two general conditions: on the one hand simple pleural involvement, on the other hand pulmonary disease with or without an affection of the pleura, the main thing to be determined being whether the lung is or is not diseased. When the physical findings are equivocal, or even when they present absolutely no extensive abnormalities, the history and symptoms must, apart from the X-ray, be our guides in the diagnosis of extensive lesions. In deciding between a diagnosis of scattered infiltration and a diagnosis of obliterated pleura, mistakes may occur whichever decision is reached, but the point to be emphasized is that the pulmonary condition is always to be suspected and, when the symptoms are very marked, to be strongly suspected. As to the diagnosis of thickened pleura, this is usually a very difficult condition to establish clinically to the exclusion of involvement of the lung. Not only is this diagnosis often difficult, as has been demonstrated repeatedly at operation and in the postmortem room, but it is a comparatively rare thing for much thickening of the pleura to occur in cases of tuberculosis that have been free from pleural fluid, particularly purulent fluid, unless there is more or less involvement of the lung as well. Extensive infiltrative conditions in the lungs without much alteration in the symptoms, such as we see in scattered fibroid deposits, may be very difficult to distinguish from pleural conditions by physical signs alone. In some cases of fibroid phthisis our main guides are the differences on the two sides revealed by inspection, and the character of the râles. The X-ray may or may not decide the question for us; it certainly should be resorted to in doubtful cases.

The X-ray.—The X-ray as a diagnostic agent in chronic pulmonary conditions has been too highly praised by some and too severely criticised by others. If the radiographs are taken by a skilled radiologist, and interpreted by some one who is experienced in such readings and knows the limitations of radiography in pulmonary conditions, they will in certain selected cases, though not in all of them, add greatly to the information acquired by physical signs. The X-ray is particularly useful in the type of cases referred to in this paper, in which the lesions are supposed to be extensive because of the history and symptoms, though this suspicion is not corroborated

by the physical findings. A number of cases are subjoined illustrative of this point. (See Cases Nos. 1, 2, and 3, and Figs. 1, 2, and 3.)

BRIEF ABSTRACTS OF ILLUSTRATIVE CASE REPORTS

CASE No. 1.—To illustrate marked pulmonary involvement as revealed by the X-ray, associated with but few and slight variations in the physical signs; marked dyspnœa a distinctive symptom. Duration of symptoms very suggestive.

J. J., Phipps, No. 11,307, admitted January 4, 1913. A man aged 30. The patient has had a hacking cough for the past 15 years, but felt perfectly well until four years ago, when he was attacked with a severe cold, associated with pleurisy on the left side and dyspnœa. The dyspnœa has never left him, being always marked on slight exertion; the pains in the left side have also been fairly constant. He had a distinct attack of pleurisy three years ago, and another two years ago. Expectoration developed 18 months ago, the amount varying between a half ounce and a half cupful. About the time of the onset of the latter symptom hæmoptysis appeared for the first time, and has been recurring ever since at intervals of two to five weeks, the largest quantity, according to his statement, being about three quarts in 24 hours. Occasionally there have been slight night-sweats. Height, six feet. Highest and ordinary weight before he became sick, 168 pounds. He has not lost any weight, but has weighed as high as 178 pounds since beginning treatment. Weight on admission, 170½ pounds. Temperature, pulse, and respiration normal. Sputum repeatedly negative. Von Pirquet positive. Wassermann negative.

Physical Examination.—Tall, large-framed, well-nourished man, a little pale in appearance. Nails not curved. Clavicles unduly prominent as compared with the general nutrition of the body. Expansion poor, a little less on the left side. Right apex supposed to be definitely involved, left apex suspicious. Below the second ribs in front and the spines of the scapulæ there are no abnormal signs except for weak breath sounds everywhere, a little weaker and more muffled over the left side than the right, with very slight dulness over the left side in front. Radiographs (Fig. 1) were made by Dr. Pancoast, at the time of admission and a year previously, showing much the same condition on both occasions; namely, considerable pulmonary involvement (regarded as tuberculous) on both sides, but decidedly more on the left. There is marked infiltration around the root of the right lung, and less at the base. On the left side there is some involvement throughout, slight above, quite marked below, with possible cavity formation.

CASE No. 2.—This illustrates extensive disease suggested chiefly by hæmoptysis, marked drumstick fingers, and diminished expansion on one side.

L. P., Phipps, No. 11,236. A woman, 24 years old. Onset four months ago with cough, which has continued and has been associated with slight expectoration, always negative for tubercle bacilli. Menstruation is suppressed. There have been two hæmoptyses within a month. (Several more followed shortly after admission.) Slight nocturnal dyspnœa. No change in weight. (Weight 153 pounds, height 5 feet 4 inches.) Wassermann negative. Temperature slightly elevated at times. Physical examination shows a very stout girl with marked drumstick fingers. On admission, and repeatedly thereafter, examination revealed nothing abnormal in the chest except at the right apex, and also constantly diminished expansion over the left side, and occasionally a little weaker

Fig. 1.

To illustrate extensive pulmonary infiltration with comparatively slight changes in the physical signs. (Case I.)

Fig 2

To illustrate extensive pulmonary infiltration with comparatively slight changes in the physical signs. (Case II)

breathing than on the right. The X-ray, taken by Dr. Pancoast (Fig. 2), shows infiltration below the right apex, and probably an area of consolidation about the second interspace. There is considerable infiltration on the left side, and this is much more marked and widespread at and below the apex than on the right side. "The appearance strongly suggests a thickened pleura low down and in the region of the axilla."

CASE No. 3, which illustrates extensive involvement as revealed by X-ray and not by physical signs; also the obscurity in physical findings when preternaturally weak breath sounds are everywhere present.

J. G., University Hospital Medical Dispensary, No. A. 6632, a man, 29 years old, tinner by occupation. Admitted December 2, 1912. History of exposure: for seven months nursed his step-father, who died of tuberculosis in 1907. Heavy cigarette smoker. His present illness dates back one year, at which time he had an attack of pleurisy. Since that time he has had a constant cough and his health has been failing. Expectoration appeared and is now considerable in amount. There has been no dyspnœa, but marked weakness has developed. He is subject to pains in the right side of the chest and in the left shoulder and arm. Night-sweats have been profuse. Hæmoptysis absent. The temperature has been as high as 104° F. His weight has fallen in three months from 168 pounds to 138 pounds. No tubercle bacilli were demonstrated in the sputum at the time of admission, but appeared later. At the first examination on December 19, 1912: Patient appears very weak and ill. Nutrition poor. Chest expansion poor, but equal on the two sides. Vocal fremitus very weak everywhere, but greater over the right side. There is moderate dulness above the right clavicle, slight below it, and also above the left. Moderate dulness at right apex posteriorly and slight at left. Slight dulness over the root of the right lung and below this in the right interscapular space. Breath sounds very weak everywhere, but not otherwise modified. Questionable râles at right apex on coughing. Vocal fremitus + at right apex anteriorly and posteriorly. Whispering pectoriloquy absent. X-ray (Fig. 3). *Right lung:* Whole side more hazy than left; quite dense irregular shadow over upper half of lung; striated shadows very marked at root of lung and branching out along the course of the bronchi. *Left lung:* Quite dense infiltration around the root of the lung.

CASE No. 4.—To illustrate unrecognized but extensive involvement in the presence of compensatory emphysema. J. J. C., Henry Phipps Institute, No. 7791. Advanced pulmonary tuberculosis. Examination 15 days before death. Left side very markedly involved, and the right side only is herewith described. Right side, *physical examination:* Greater expansion than on the left. Slight increase in the vocal fremitus to the second rib. Dull above clavicle and slight dulness to third rib. Bronchial breathing above clavicle, weak breathing below to third rib. Râles as far down as third rib. Vocal fremitus slightly + to third rib. Whispering pectoriloquy close to the sternum in the third interspace. Posteriorly: at the apex there are increased vocal fremitus, and vocal resonance, slight dulness, bronchial breathing, and râles. The signs are normal below the apex except for exaggerated breath sounds. *Autopsy,* right lung: The lung is markedly enlarged. Along the anterior margin in front, extending from below the apex nearly to the base and inward about 2½ inches, is an area composed of almost complete caseation. Elsewhere throughout this lung there are only a few scattered tubercles. Compensatory emphysema marked.

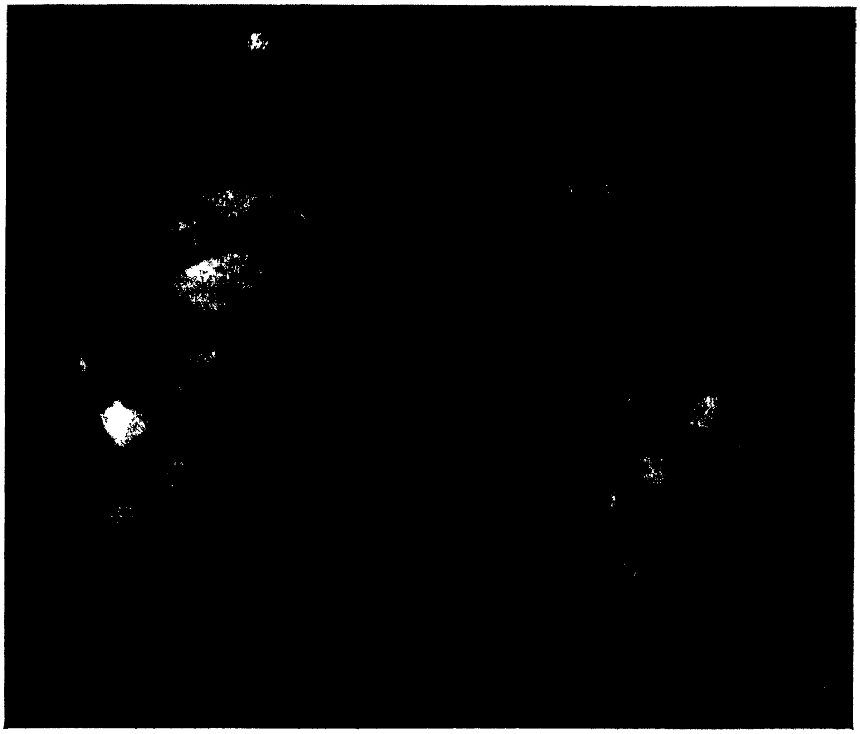
Case No. 5.—To illustrate unrecognized extensive involvement in the presence of compensatory emphysema. K. L., Phipps, No. 6162. Left lung entirely involved and functionless. Notes cited refer to right lung. Physical signs right side anteriorly: expansion greater than on left. Vocal fremitus + to second rib. Slight dulness above clavicle, impaired hyperresonance below clavicle, everywhere below this hyperresonance. Cavernous breathing as far down as the second rib, bronchial in the second interspace, bronchovesicular in the third interspace, normal below. Râles, bubbling to the second rib, occasional fine in the second and third interspaces. Vocal resonance + to the third rib. Whispering pectoriloquy to the second rib. Posteriorly vocal fremitus + at apex. Dulness at apex, and slight dulness just below. Cavernous breathing at apex and bronchial at level of spine of scapula. Harsh vesicular breathing elsewhere. Râles bubbling at apex, large and moist just below this. Vocal resonance + upper half of back. Whispering pectoriloquy at apex. *Autopsy*, right lung: Very slight thickening of pleura over upper lobe. Cavity at apex 2½ cm. in diameter. Just below this are a similar cavity and several smaller ones, the rest of lobe being largely occupied by caseous pneumonia and conglomerate tubercles. Middle lobe is consolidated throughout with caseous pneumonia and many conglomerate tubercles. Lower lobe: The upper portion is consolidated with caseous bronchopneumonia and conglomerate tubercles, and there are a few cavities of moderate size; the rest of the lobe is emphysematous and congested.

Case No. 6.—To illustrate infiltration, chiefly central, obscured by the presence of compensatory emphysema. R. W., Phipps, No. 2490. Examination six weeks before death. The right side throughout showed signs of very extensive and marked involvement, which were corroborated by autopsy. On the left side there were dulness at the apex anteriorly and posteriorly, and hyperresonance elsewhere. Occasional râles at the apex anteriorly and posteriorly, and at the base posteriorly. Exaggerated breath sounds were present everywhere. *Postmortem* revealed cavity formation an inch below the surface at the apex, with marked scattered infiltration throughout a large part of the lung, due to the close approximation of smaller and larger tubercles. The nearest approach to complete consolidation was in the central portion of the lung. A narrow strip of healthy tissue formed most of the periphery of the lung.

Case No. 7.—To illustrate extensive disseminated tuberculosis presenting signs sometimes interpreted as indicating a thickened or adherent pleura. E. P., Phipps, No. 5260. Over the lower lobe of the left lung there were diminished motion, diminished vocal fremitus and vocal resonance, impairment on percussion, and numerous fine crackling râles which almost entirely obscured the breath sounds and rendered recognition of their character impossible. At autopsy (made three months after the above record) the pleura was found obliterated down to the fifth rib posteriorly, below which there were no adhesions. The whole lower lobe was riddled by small tuberculous nodules measuring from ½ to 3 mm. in diameter. At the apex of the lobe along the anterior margin there were three or four communicating cavities measuring 1 to 3 cm. in diameter. (The left upper lobe was extensively involved with infiltration and excavation.)

Case No. 8.—To illustrate the presence of marked constitutional symptoms, especially dyspnœa, in association with very slight changes in the physical signs, although it was probable that quite extensive disease existed, as the

Fig. 3.



To illustrate extensive pulmonary infiltration with comparatively slight changes in the physical signs (Case III.)

patient died ten months later without any special accidents. M. McC., Phipps, No. 3182. The patient dates her illness back to two months ago, when persistent cough and expectoration developed, but she had been suffering with dyspnœa on exertion for a year following a cold on the chest of two months' duration. She was attacked with pleurisy six months ago. Expectoration amounts to two or three ounces. The sputum, negative on admission, became positive five months later. In the six months prior to admission her weight dropped from 100 pounds to 95 pounds. Pulse 112–124, temperature 100° in the morning, respiration normal. Disease contracted from her mother. *Physical examination:* Apart from findings at the right apex that could not be definitely regarded as more than physiologic, the chest revealed nothing abnormal except constant fine râles at the right base posteriorly. Six weeks later râles developed at the left apex, and the patient died ten months after admission. Cause of death, very extensive bilateral pulmonary tuberculosis, with cavity formation.

Case No. 9.—The case herewith presented belongs to a type not infrequently met with exhibiting the difficulty or even impossibility of determining whether a pulmonary or pleural lesion is present.

M. S., 49 years old, widow, housewife, presented the signs of a well-marked mitral stenosis, cardiac enlargement, and myocarditis with failing compensation. She still suffered from the effects of a left-sided paralysis dating back four years and attributed to an embolus.

The evidences, apart from the pulmonary signs, that suggested a diagnosis of tuberculosis were: (1) The fact that her husband had died of pulmonary tuberculosis after an illness of 3½ years, during at least a part of which time he had been particularly careless about preventive precautions. (2) She had suffered from influenza, as she called it, every winter for 20 years, and had never been normally strong. She had lost 8½ pounds in five weeks, but was still fairly well nourished, her ordinary weight having been 123 pounds, while her height was 5 feet 1½ inches. She gave no history of pleurisy or hemorrhages. The sputum had always been scant or absent. There was no rise of temperature during the time,—almost four months,—she was under observation. She gave only a very poor von Pirquet reaction.

Lungs.—There were some signs of involvement at the left apex, particularly dulness, but the most extensive and marked signs were on the right side, which was a little flatter than the left, while expansion was poor on both sides. Against the diagnosis of tuberculosis was the fact that the clavicles were almost invisible when the patient was in a sitting position. On the right side dulness extended to the second rib anteriorly, being combined with slight tympany, while posteriorly there was dulness to the spine of the scapula. Vocal resonance was increased to the third rib in front and to below the spine of the scapula posteriorly. Whispering pectoriloquy occurred above the clavicle, and was present in a slight measure at the apex posteriorly. The breathing was obscure bronchial above the clavicle, and harsh at the apex posteriorly where inspiration was obscure and expiration prolonged. Moist crackles were heard at the apex posteriorly. The changes over the rest of the right lung consisted in marked diminution in the breath sounds, with moist crackles all over the back, and obscure, medium-sized, rather moist râles below the second rib to the base anteriorly.

The physical signs seemed to point to some pulmonary infiltration at the right apex and to pleural involvement with pulmonary congestion or some degree of infiltration over the rest of the lung. The history and predominance of signs at the right apex,—perhaps partly as the result of passive congestion of the lungs,—favored a diagnosis of tuberculosis, although the process was supposed to be arrested.

Autopsy revealed no signs of tuberculosis. The left lung and pleura were normal. The right lung was normal, but the pleural cavity was nearly everywhere completely obliterated by adhesions which, though not specially thick, were firm enough to anchor the lung very tightly in places to the chest-wall. The bronchial glands were slightly enlarged and markedly anthracotic.

Heart.—All the valves except the pulmonic showed some thickening. The aortic valves were moderately thickened, but seemed capable of fair functionation. The tricuspid was decidedly more thickened, and admitted less than two fingers. The mitral valve furnished a striking example of the button-hole opening, barely allowing the passage of a pencil. Both auricles were much dilated, and the left contained a thrombus the size of a lemon.

FACTORS IN THE CLINICAL PHYSIOLOGY OF THE HEART

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THE NORMAL TASKS AND POWERS OF THE HEART

No adequate conception of the origin or tendency of a cardiac disorder can be formed without a comprehensive insight into the anatomy and physiology of the heart. In the following paragraphs an effort will be made to select for discussion a few of the teachings of anatomy and physiology which it behooves the clinician especially to bear in mind.*

The heart is essentially a force-pump whose main purpose is, through contraction of its ventricles, to overcome the arterial pressures closing the semilunar valves and rhythmically to expel a certain amount of blood. It may be surmised that not one of the numerous, apparently adventitious, movements executed in the performance of its function is without use in aiding the heart in its work.

Musculature of the Heart.—Physiologists will doubtless ere long point out the peculiar adaptiveness to its function of the curious musculature of the heart. It was long believed that the contractile tissues of the mammalian auricles and ventricles were completely separated by a ring of fibrous tissue at the auriculoventricular junction. According to this view, coördinate action between auricles and ventricles could only be secured by nerves passing from one set of chambers to the other. It has recently been proved, however, that a protoplasmic connection exists in the heart of man and certain mammals in the form of a bundle of peculiar fibres of conductive and presumably contractile tissue situated in the septa between the two sides of the heart. This "auriculoventricular bundle," as dissected from the septum between the auricles, is only 18 mm. long by 1.5 to

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* For a satisfactory elementary discussion of this subject, consult Howell's "Textbook of Physiology," 4th Ed., 1911.

2.5 mm. wide; it "springs from the right side of the interauricular septum, runs obliquely through the connective tissue, and ends in the muscle of the ventricular septum under the origin of the aorta."[1] Later investigations have shown the anatomical distribution of this "bundle of His" to be much more extensive than was at first believed. Aschoff describes,[2] from the researches of Tawara,[3] the fasciculus of fibres as inclosed in a connective-tissue sheath running down the interventricular septum immediately under the endocardium and branching to find its termination in the various papillary muscles. Throughout its progress, also, the main bundle gives off side branches which end in the musculature of the ventricular walls; among the fleshy threads which form the bulk of the auriculoventricular bundle are included many ordinary nerve-fibres.

The modern conceptions of the physiology and pathology of the heart are founded on the facts of embryology and comparative anatomy.

In the primitive heart, an organ perhaps best represented in the eel, there were three contractile chambers,—the sinus venosus, the auricle, and the ventricle. The heart-beat was initiated in the sinus, whose tissue connected not only with the auricle but by a narrow strip with the ventricle as well. In the evolution of the mammalian heart the sinus, as a distinct chamber, has been lost, but the primitive tissue with its primitive automatic functions has been preserved and incorporated in the walls of the organ as we know it. There is a histological differentiation of tissue in the wall of the mammalian right auricle in two situations. These little islands of supposedly primitive tissue are composed of peculiar muscle-fibres, nerve-cells, and nerve-fibres, and are designated as *nodes*. One of them, discovered by Keith and Flack,[4] known as the sino-auricular node, is situated in the auricular wall between the openings of the venæ cavæ. According to prevailing views, it is normally the pacemaker of the heart, the site of evolution of the contractile impulses. The other node, discovered by Tawara, is found on the right face of the interauricular septum near the mouth of the coronary sinus. It is known

[1] Howell, "Textbook of Physiology," 1907, p. 496.

[2] Aschoff, *Zentralbl. f. Physiologie*, 1905, xix, 298.

[3] Tawara, "Das Reizleitungssystem des Saügethierherzens," Jena, 1906.

[4] Keith and Flack, *Jour. Anat. and Physiol.*, 1907, xli, 172.

as the auriculoventricular node, and gives origin to the conducting bundle of His. The node has especial clinical interest from the fact that in that common pathological state in which the auricles and ventricles contract simultaneously, or have their normal rhythm reversed, this node is supposed to assume the function of pacemaker to the heart. The beat is then said to represent the "nodal rhythm." As recently set forth by Erlanger,[5] we have yet much to learn of the anatomical distribution of the remains of the primitive heart tube in the mammalian organ, and far more as to its physiological attributes. Nevertheless, we are justified in the conception that, preserved in the mammalian heart, are histologically distinguishable remnants of primitive tissue represented in the nodes referred to above, in the bundle of His, and probably in yet undefined connections and ramifications of like tissue, bringing it into anatomical relation with a large part, if not the whole, of the differentiated musculature of the heart. We cannot escape the conclusion that, functionally, to this primitive tissue are relegated especially the automatic, the rhythmic, and the conductive powers of the heart. There is a graded irritability of different parts of the system of primitive nodes and fibres, and many cardiac disorders familiar to the clinical student have their origin in disturbance of the normal play of impulses within it.

The Automaticity of the Heart.—It is interesting to observe that this subject, which until recently found a debating ground confined to pure physiology, has now become of practical interest to the clinical student. Science has not yet developed the full relations of nerve and muscle in carrying on the heart-beat; but the clinical disturbances of cardiac rhythm are greatly illuminated by the conception that different regions of the heart possess inherent automatic contractile powers, the spontaneity of one part being, so to speak, more acute and its natural rhythm faster than that of another. Under normal conditions the area of most acute spontaneity furnishes contractile impulses along intervening conductive tissue to neighboring areas whose normal rhythm is slower and less easily excited than that of the first. Hence the more irritable automatic area, although its mechanical power may be insignificant, acts as a "pacemaker" for the whole heart.

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[5] Jos. Erlanger: "The Localization of Impulse Initiation and Conduction in the Heart," *Arch. of Int. Med.*, 1913, xi, 334.

Erlanger and Blackman [6] conclude from their experiments on rabbits that "The region of the right auricle in the vicinity of the mouths of the great veins is possessed of the highest degree of rhythmicity. In at least a vast majority of instances this region normally sets the pace of the whole heart." They found that the interauricular septum and all parts of the right auricle possessed a degree of rhythmicity only less than that of the region first mentioned, but that the left auricle, isolated from the septum, is not spontaneously contractile. "Partial and complete block may be established between any two parts of the auricles, provided one of the parts is spontaneously rhythmical, by narrowing the functional connection between them. When a transitory complete block is established in this way, the less rhythmical part stops beating, but in case it possesses spontaneous rhythmicity, it will soon begin to beat again, first in complete block and then in partial block, with all the rhythms which have been observed, for example, in transitory auriculoventricular block." The "block" here spoken of results from a local depression of physiologic conductivity in the tissue joining a more irritable to a less irritable automatic area.

The subject is best understood in the light of investigations on the "Stokes-Adams syndrome." In this disorder the rhythm of the ventricles is slower than that of the auricles. After the auriculoventricular bundle of His was discovered, it was found by autopsy in a number of cases that the Stokes-Adams phenomenon was associated with a lesion in the bundle evidently capable of interfering with its conducting power. Then Erlanger [7] demonstrated on dogs that mechanical compression of the auriculoventricular bundle by a specially-constructed clamp could cause every variety of dissociation of the rhythms of auricles and ventricles. When the bundle of His was completely crushed the ventricles stopped beating for a while, but later recommenced with a rhythm of their own, having no relation to that of the auricles. This is a "complete block." When the clamp was screwed less tightly the conductivity of the auriculo-

[6] Erlanger and Blackman: "A Study of the Relative Rhythmicity and Conductivity in Various Regions of the Auricles of the Mammalian Heart," *Amer. Jour. Physiol.*, 1907, xix, 125.

[7] J. Erlanger: "On the Physiology of Heart-block in Mammals, with Especial Reference to the Causation of Stokes-Adams Disease," *Jour. Exp. Med.*, 1906, viii, 8.

ventricular bundle was lowered but not abolished; the clamp could be adjusted so that only every second, third, or fourth auricular impulse, suggesting a "summation of stimuli," was found effective in producing a ventricular contraction. This gave a cardiac rhythm in which two, three, four, or more beats of the auricles occurred to one of the ventricles. The condition illustrates a "partial block."

These facts have already been successfully applied to explain some of the common forms of heart irregularity met in clinical practice.

It is not the business of the auricles to do much work, and accordingly their musculature is relatively thin. A superficial layer of fibres runs horizontally and encircles both chambers. Another layer of muscle runs at right angles to the foregoing, the fibres being attached at their ends to the auriculoventricular ring, and surrounding the auricles separately. The musculature of the ventricle is of much greater complexity. According to J. B. MacCallum,[8] who has most exhaustively worked out this subject, of the several layers of muscle of which the ventricles are composed, "nearly all begin in the auriculoventricular ring of one ventricle and end in the papillary muscles of the other. Those fibres which begin near the outside of one ventricle end near the inside of the other ventricle."

Such an arrangement gives the majority of the fibres a spiral course, and their contraction must tend to shorten each diameter of the ventricles. This arrangement of the heart-fibres suggests the mechanics of the "lifting machine"; one stands on a movable platform and pulls upward upon the handles; both the downward push and the upward pull are added together in the registered result. In the heart the auriculoventricular ring forms the fulcrum, and the power is applied to the closed auriculoventricular valves. The significance of this arrangement in pathological conditions will be touched upon later.

The Work of the Heart.—The measure of the worth of a heart, other things being equal, is its power of doing work. The work accomplished by the whole heart in a given time is determined by the amount of blood thrown out multiplied by the resistance overcome. More exactly, the work done by each ventricle at any systole

[8] J. B. MacCallum: Contributions to the Science of Medicine, dedicated to W. H. Welch, Baltimore, 1900, p. 307.

is expressed by the formula $W=pR+\frac{pv^2}{2g}$, in which p is the weight of blood expelled; R is the mean arterial blood-pressure, or resistance offered to the opening of the semilunar valves; v is the velocity per second imparted to the blood; and g the acceleration produced by gravity. As the mean blood-pressure in the pulmonary artery is only about one-third of that in the aorta, the work done by the right ventricle is correspondingly less than that performed by the left. Nevertheless, the amount of blood pumped from each ventricle must, in the long run, be exactly the same. Supposing that at each systole the right ventricle expelled a single drop of blood in excess of that leaving the left ventricle at the same time, in less than a day all the blood of the body would be gathered in the lungs. If, on the contrary, the output from the left ventricle was steadily in excess, the pulmonary circulation would be drained, and the blood accumulate in the systemic vessels. These conceptions emphasize the all-important clinical truth that life depends not so much on the absolute amount of energy manifested in the expression of a specific function as on the preservation of a certain balance between coördinate physiological processes. There may be considerable variation in the rate of outflow from the heart in the course of an hour without physiological disturbance, but the variation must affect both sides of the organ equally, otherwise disaster will follow. Just as soon as the balance between the output of the two ventricles is disturbed, there is initiated a series of events which leads to vital ruin unless, by a process of "compensation," the strength of the ventricle behind the point of obstruction is sufficiently increased, or the resistance to circulation in front of it is sufficiently diminished. The problem of cardiac therapeutics is frequently how to restore the balance in the work of the two ventricles, and thus bring about a normal distribution of the blood mass. The normal output from each ventricle of the human heart at its systole is estimated to vary between 50 and 100 Cc. (1.7 and 3.4 fluidounces).

Yandell Henderson[9] describes experiments on the dog's heart in which the ventricles were inclosed in a plethysmograph, a chamber connected with a recording tambour, by which the changes in volume of the cavities—therefore the amount of blood entering and leaving

[9] Yandell Henderson: "The Volume Curve of the Ventricles of the Mammalian Heart," etc., *Amer. Jour. Physiol.*, 1906. xvi, 325.

them—could be registered. According to this author, the cardiac cycle is properly divided into three phases instead of two, as is usual, namely: "Systole, the period of contraction and discharge; diastole, the period of relaxation and filling; diastasis, the period of rest." During systole of the ventricles these chambers are more or less completely emptied, 90 per cent. of the contents being expelled at a very rapid and uniform rate, and the remainder more slowly. In a normal and vigorous heart, at the end of systole with the opening of the auriculoventricular valves, "the refilling of the ventricles occurs early in diastole,—it is as rapid a process as is the systolic emptying." The period of *diastasis* includes the latter part of diastole between the completion of the diastolic filling of the ventricles and their succeeding systole. When the frequency of the heart-beat is increased the period of diastasis is shortened, and the greatest output of blood within a given interval of time occurs when the period of diastasis is completely obliterated and when systole immediately succeeds the previous diastolic filling. This is the "optimum" rate of beat. When the beats are still more frequent, each systole may succeed the preceding before the ventricle has had time completely to relax; the volume of blood pumped out at each beat may therefore be so much reduced that in spite of increase in frequency the total output of the heart is not increased. In most cases the period of diastasis is marked, not by complete stasis but by a slow and continuously decreasing inflow of blood into the ventricles. According to Henderson, with a slow normal rhythm the tone of the cardiac muscle prevents the complete relaxation of the ventricles, as proved by the fact that with inhibition through stimulation of the vagus nerve their volumes are gradually increased 10 to 15 per cent. "Nor at such rhythms are their chambers emptied by systole; from 20 to 30 per cent. of their diastolic volume is retained" at the completion of the contraction.

With a rapid rhythm the systolic emptying is more complete, roughly in proportion to the rate, and the relaxation and diastolic filling are less so. At all rates of beat below the optimum rate, the volume discharge is nearly uniform. These conclusions have considerable importance as a basis for clinical conceptions.

The Relation between the Size of the Contracting Cavity and the Strain upon its Walls.—It may be presumed that the nutritive de-

mands of the whole organism are sufficiently met by any cardiac action which sustains a rate of blood movement in excess of a certain minimum. It is obvious that the output from the heart and the work done may remain the same under widely different conditions of rate of beat and amplitude of movement. A ventricle may expel 100 Cc. of blood at systole either by complete contraction preceded by moderate diastolic expansion, or by incomplete contraction following excessive relaxation.

It is easy to demonstrate that, whereas the results accomplished may at the outset be equally good, the physiological effect upon the heart of the two modes of action may be in one case conservative and in the other disastrous. It has been shown in a preceding article that the vigor of the coronary circulation depends directly upon the completeness of ventricular systole, and that the blood flow through the walls of the heart becomes more languid with dilatation of the organ. It seems probable that the optimum of cardiac nutrition can only be maintained by a movement in which systolic contraction is complete and the ventricular cavities are emptied as nearly as may be. It may reasonably be supposed that, under this condition, the volume of blood flushing the coronary vessels increases with diastolic expansion. Therefore, the deduction should be emphasized that, to maintain vigorous cardiac nutrition, not only must the amplitude of heart movement be considerable, but systolic contraction should be at times complete. Unfortunately there is as yet no direct means for the clinical determination of this functional activity. If we may generalize from the views of Henderson, expressed above, a rational hygiene of the heart demands equally a slow rhythm, during which alone diastolic relaxation can be complete, and a rapid rhythm without which the ventricles are not emptied at systole. That is to say, physiological experiment furnishes an explanation of common and clinical experience that an alternation of bodily rest and exercise, through which these varieties of rhythm are induced, is best adapted to strengthen the heart.

But there is also a mechanical view of the heart-beat which clears up many of the difficulties of the clinical problem. It is a familiar principle in hydraulics that the pressure sustained by the wall of a vessel filled with fluid is proportioned to the area of contact. If, for example, such a surface comprises 100 square inches,

and a pressure of one pound be applied to the fluid through a tubular aperture having a cross section one inch in area, every square inch of the interior of the vessel will sustain the pressure of one pound, and the total surface of the cavity will be strained by a force of 100 pounds. Transferring this abstraction to the case of the heart, it is obvious that, in overcoming a definite aortic blood-pressure, the total strain upon the wall of the ventricle must be much greater when the organ is in diastole than when it is in systole, and that the strain, the resistance remaining the same, diminishes progressively during contraction. It is clear, also, that the physiological burden dependent upon dilatation of the heart is amply explained by the mechanical conditions. Since the heart-wall does not change its mass during the cardiac cycle, there must be fewer muscular fibres subtending each unit of area of the ventricle in diastole than in systole, hence the strain upon each individual fibre is increased in the former state. In his discussion of this subject, Hill[10] says: "When the exertion of each individual fibre is taken as constant, the fluid pressure per unit area must vary inversely as the cube of the radius of curvature; or, if the pressure be regarded as constant, the exertion of each fibre must vary as the cube of the radius of curvature." Thus it is mathematically demonstrated that the dilated heart works under a tremendous mechanical disadvantage, and it is easy to conceive that the overstretched muscle might be quite unable to contract. Such paralysis is probably a fairly constant affliction of the auricles in the late stages of most heart-diseases. Hill[11] has experimentally produced a like condition in the right ventricle of an animal whose heart muscle was weakened through profound chloroform narcosis. When blood was injected into the right ventricle by means of pressure applied to the abdomen, the ventricle readily suffered a paralytic distention.

The Inverse Relation of Work Power and Length of Fibre in a Contracting Muscle.—While the properties of the cardiac muscle appear sharply to distinguish it from the skeletal muscle, the laws of contraction in the latter may profitably be used to form a working hypothesis to extend our knowledge of the former. It is a familiar

[10] Leonard Hill: Schäfer's "Textbook of Physiology," vol. ii, p. 40.

[11] Leonard Hill: "The Influence of the Force of Gravity on the Circulation of the Blood," *Jour. of Physiology*, 1895, xviii, 15.

fact that when a skeletal muscle, having parallel fibres, is excised and suspended by one end, the load which it can support when artificially stimulated to contract diminishes as the muscle shortens. The lift power of the muscle is greatest when the muscle is at its greatest length, and is least at the phase of maximal contraction. Conversely, a given weight attached to the end of a fully elongated muscle stretches it but little; the same weight suspended from the muscle at the extreme height of its contraction stretches it a good deal. In other words, as a muscle shortens its elasticity diminishes and its extensibility increases. The actual relations of the voluntary muscles to the long bones of the skeleton prove the vital economy of this principle. Thus, when the arm is straight, the biceps muscle in bending the elbow must expend most of its energy in pulling together the two bones, a very small component being effective in raising the lever; but as the forearm is raised, according to the law of the parallelogram of forces, a progressively greater proportion of the energy of contraction is devoted to the useful purpose for which the muscle is intended. That is, the abstract law of muscular contraction is so harmonized with the local conditions in the body that the effective component of the contractile energy shall remain fairly uniform under extreme differences of mechanical resistance. Moreover, the increased extensibility of the contracting muscle appears to be of a conservative nature, and adapted to preserve the body from mechanical injury. In a person who is suddenly impressed with the anticipation of a physical shock there is an involuntary increase of tension in the whole musculature, and the muscles about the part at which the hurtful impact is expected are vigorously contracted. We can hardly doubt that the safety of the body is enhanced by the binding together of its moving parts with cords of increased extensibility which may be stretched to an extreme without overstrain. Turning again to the consideration of the cardiac problem, it has already been made clear that in order to overcome a given resistance the wall of the ventricle works under a strain which increases with the cube of the radius of its cavity. If it could be shown that the cardiac, like the skeletal, muscle-fibre increases in strength with its length, we would witness here one of those frequent compensations which go to preserve the balance between power and resistance.

Furthermore, building upon the analogy of the skeletal muscle, it may be suspected that the physical property of extensibility is magnified in the cardiac muscle during the act of contraction. That is to say, a weak systole is apt to be an ineffective systole, incapable of opening the semilunar valves, simply because the stretching effect of the intracardiac load exceeds the lifting power of the muscle at the height of contraction. In a later section it will be shown that the resistance to expulsion of blood from the ventricle increases from minimal to maximal very early during the period of expulsion; consequently it is easy to see that the increasing extensibility of the muscle during contraction may at any time in the ventricular systole cause the stretching of the fibres under strain to equal their functional shortening. If these forces balance during the period of "rising tension," the semilunar valves are not opened and the systole is completely ineffective; if the balance occurs during the expulsion period of the systole, the output of blood is cut short at that moment, and the expulsion time is shortened. In either case the quantity of residual blood remaining in the ventricle after incomplete contraction is increased, and the first step is taken toward a possible pathologic dilatation of the heart.

But it is the object of this discussion to make clear that the physiologic processes within the heart by no means suffer nor are they altered, except in degree, by reason of this ineffective systole. The assumed increase of extensibility of the cardiac muscle with contraction, although it may lead to temporary ineffectiveness of the force-pump, is probably wholly conservative in its tendency; for it must save the muscle substance from overstrain and trauma such as might threaten it, for example, during the excessive momentary rise of arterial pressure which may accompany sudden violent muscular exertion.

After such an ineffective systole the diastolic content of the ventricle is increased, and it might be anticipated that the organ which has been too weak to expel a small load must completely balk at the task of moving a larger one. There comes now into play, however, a curious but definitely proved compensatory reaction, which may be expressed by saying that *mechanical distention acts as a stimulus to the resting heart.* Physiologists agree that a ventricle which

is quiescent or but freely pulsating may be brought into powerful action by stretching, without overstraining, its walls.

Miss Hyde,[12] in her work on the influence of cardiac dilatation on the coronary blood flow, specifically mentions the difficulties experienced in producing distention of the cardiac cavities without at the same time inducing strong contractions. The familiar clinical fact that the diastolic pause following an ineffective or a minor systole is apt to be prolonged provides the cardiac muscle not only with an extra period of rest, but adds to the strength of the stimulus for the succeeding contraction. Moreover, as will be pointed out later, the resistance to outflow from the ventricle becomes less the longer the diastole is continued.

The Variation of Resistance to Ventricular Output Dependent on Pulse Pressure.—The mechanical purpose of the heart is to overcome the resistances opposed by the arterial pressures to opening of the two sets of semilunar valves. Such resistance varies, of course, with the height of arterial blood-pressure. The sphygmomanometers in ordinary use enable us to determine systolic blood-pressure with fair exactness by reading the height of a column of mercury which is sustained by the air-pressure within a cuff round the arm when the pressure barely allows the escape of blood through the compressed brachial artery. But inspection of a sphygmogram shows that the blood-pressure begins to fall early during the systolic outflow from the ventricle, and continues to fall more slowly after closure of the semilunar valves, throughout the diastole, until the moment of the next ventricular contraction. Here we find the minimal or so-called diastolic blood-pressure. The valuable work of Howell and Brush [13] has shown that the diastolic pressure is reached when the pulse oscillations on the mercurial column of the manometer attain their greatest amplitude as the tension within the cuff is relaxed. In normal subjects the minimal blood-pressure amounts on the average only to about two-thirds of the maximal pressure. This difference between maximal and minimal arterial pressures occurring in the same cardiac cycle has been called by Erlanger and Hooker [14] the

[12] Ida H. Hyde: "The Effect of Distention of the Ventricle on the Flow of Blood through the Walls of the Heart." *Amer. Jour. Physiology*, 1898, i, 215.

[13] Howell and Brush: *Boston Med. and Surg. Jour.*. 1901, cxlv, 146.

[14] Erlanger and Hooker: *Johns Hopkins Hosp. Rep.*, 1904, xii, 145.

pulse pressure, and its absolute value and its ratio to the highest and lowest pressures have been shown to have extraordinary physiological and pathological importance. Its normal ratio to systolic pressure is said to be as 1 to 3. It is the amplitude of the pulse pressure which determines the "largeness" of the pulse as felt at the wrist. Experimental evidence collected by many observers [15] shows that the pulsatile movement imparted to the blood in the tissue arterioles is of the highest consequence in maintaining a normal peripheral circulation and normal cellular activities, but I know of no appreciation of the importance of pulse pressure as determining resistance to outflow from the heart.

Just before the ventricle contracts, its wall is at its maximum distention and, according to the principles enunciated above, the mechanical strain upon its individual fibres is the utmost, other things remaining the same, varying as it does with the cube of the radius of curvature. But at this moment the aortic resistance is at its minimum, which, with a given maximal pressure, is smaller the greater the pulse pressure. When the semilunar valves are thrown open the arterial resistance rises rapidly as a consequence of the outflow. It is estimated that nine-tenths of the ventricular contents are expelled in the first two-thirds of the period of the ventricular contraction. Therefore, with the systolic rise in aortic resistance the ventricular cavity has already become progressively smaller, and the mechanical strain upon its wall is rapidly lessened.

During the latter part of the ventricular outflow the aortic resistance again diminishes progressively to the moment of closure of the semilunar valves. The student of muscle physiology cannot but suspect that this diminution of resistance is coördinated with some increased extensibility and diminished power of the cardiac muscle at the height of its contraction, as is manifested in the relations of the functioning of the skeletal muscles to the bones about a joint.

With a given maximal arterial pressure, the diastolic pressure falls to a lower point the slower the heart-beat, and, of course, the

[15] *Cf.* D. R. Hooker: "The Influence of Pulse Pressure upon Renal Function," *Amer. Jour. Physiology*, 1910, xxvii, 24. Also, A. O. Shaklee and S. J. Meltzer: "The Destructive Effect of Shaking upon the Proteolytic Ferments," *Amer. Jour. Physiol.*, 1909, xxv, 81. R. A. Gesell. "On the Relation of Pulse Pressure to Renal Secretion," *Amer. Jour. Physiol.*, 1913, xxxii, 70.

slower the rate the greater the ventricular distention and, *cæteris paribus,* the greater the mechanical effort in emptying the cavity.

Henderson found in the dog's heart that the outputs from the ventricle in a given time could be identical at a rapid and a slow rate of beat, but that in the former case the diastolic relaxation of the ventricle was reduced and its systolic compression was increased; with the slower rate the diastolic relaxation was increased and the systolic compression decreased. In other words, the more rapid the beat and, presumably, the higher the diastolic pressure, the diastolic size of the ventricle was decreased, and the organ was placed under most favorable mechanical conditions for the easy expulsion of its contents. Conversely, we know clinically that a rapid rate in a dilated heart is a symptom of serious significance.

I have long been convinced that the estimation of pulse pressure, which implies a consideration of both minimal and maximal arterial pressures, is of fundamental clinical importance. Arteriosclerosis, which is at once the most common sign of vascular disease and the most constant objective evidence of the metabolic failure in senile decay, is attended usually with a characteristic elevation of systolic blood-pressure above normal.

I venture to express my clinical impression, though with lively consciousness of the unreliability of such testimony, that the characteristic pulse of the arteriosclerotic subject who is doing well as to health is a large pulse with a relatively low diastolic tension. No single sign seems to me so reassuring in the subject of stiffened arteries, or, for that matter, of any other circulatory defect, as the large pulse pressure whose diastolic value is low. Such a condition is evidence at once of slight strain opposed to the heart at its period of greatest mechanical disadvantage, and of a fair output during ventricular systole. On the contrary, to risk again the expression of clinical impressions, when in an arteriosclerotic subject—as is so often manifested in advanced nephritis—the pulse becomes "small" by elevation of the diastolic tension, cardiac overstrain is apt to be imminent. In short, other things being equal, with large pulse pressure the patient is doing well, with small pulse pressure he is doing badly. The same line of reasoning applies to our estimate of the significance of the pulse in cases suffering merely from exhaustion. According to the view here set forth, the play of arterial

resistance along the gamut of possible pulse pressures illustrates one of those resources of compensation out of which Nature arms the organism against the assaults of adversity.

It has been argued in the preceding paragraphs that the diastolic or minimal blood-pressure is the factor which determines the most critical strain upon the heart. In a valuable article Janeway[16] declares that "almost all the physiological and pathological elevations of blood-pressure affect the systolic more than the diastolic pressure." He cites numerous pathological cases, especially such as manifested aortic insufficiency, in which the pulse pressure increased enormously, up to 131 per cent. of the diastolic pressure, whereas the pulse pressure normally varies between 25 and 40 per cent. of the diastolic pressure. He writes further: "I am inclined to believe that an increased pulse pressure will be found characteristic of sclerotic changes in the large arteries, though many confirmatory autopsies and much allowance for complicating cardiac changes will be needed to give this belief real diagnostic value."

Finally, we have the crucial experimental evidence furnished by Dawson and Gorham,[17] already partially anticipated by Erlanger,[18] that the output of the left ventricle, therefore the effective work done by the heart, varies almost in proportion to the pulse pressure.

The conclusions of Dawson and Gorham are as follows: "Under normal conditions and during various procedures (namely, stimulation of the vagus centrally and peripherally, and of the *annulus Vieussens,* intravenous transfusion of 0.7 per cent. sodium chloride solution, intra-arterial transfusion of a strong carbonate, bleeding and asphyxia) the pulse pressure is a reliable index of the systolic output."

In another place Dawson[19] shows that in those conditions predisposing to "shock" there may be but little change in systolic

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[16] T. C. Janeway: "The Diagnostic Significance of Persistent High Arterial Pressure," *Amer. Jour. Med. Sci.*, 1906, cxxxi, 772.

[17] P. M. Dawson and L. W. Gorham: "The Pulse Pressure as an Index of the Systolic Output," *Jour. Exp. Med.*, 1908, x, 484.

[18] Erlanger and Hooker, *loc. cit.*

[19] P. M. Dawson: "The Systolic Output and the Work of the Heart in Their Relation to the 'Blood-Pressures' in Man," *Brit. Med. Jour.*, 1906, ii, 996.

blood-pressure, but pulse pressure is reduced by the elevation of the diastolic factor. He writes: "If we open the abdomen of an anæsthetized animal, strew the viscera over the operating table, and expose them to cooling, drying, and rough handling, we may obtain only a slight fall in the systolic pressure, while the rise in the diastolic pressure may be extraordinary."

Specific Physiologic Attributes of Systole and Diastole—The Refractory Period of the Heart—The All-or-None Law of Contraction.—Deficient as is our knowledge of the nature of the processes giving rise to the heart-beat, it is clear that, as regards certain physiological properties, the heart presents radically different states, whether considered in systole or diastole. When a skeletal muscle is stimulated by a rapid succession of induction shocks, each irritation provokes a response, and the resulting twitches are fused together in a long-continued contraction, the so-called physiological tetanus, of greater extent than could be produced by a single stimulus. When, however, an artificial stimulus is applied to the heart, its capacity for exciting a contraction depends altogether upon the functional state of the organ when the irritation strikes it. Throughout the period of systole the ventricle appears to be devoid of irritability, and the contraction proceeds unchanged in rate and power. This so-called "refractory" period of the heart prohibits the genesis of a tetanus in the organ in contrast to the ready summation of contractions which may be induced in the skeletal muscle. On the contrary, while the ventricle is relaxing, or during the diastolic pause, a stimulus very readily provokes a contraction. In short, during systole the heart muscle is unirritable, during diastole it is irritable to artificial stimulation.

Another specific feature of cardiac irritability is manifested in the want of relation between the strength of a stimulus and that of the contraction resulting from it. In the skeletal muscle it is possible, by graduating the intensity of a series of induction shocks, to obtain a series of contractions, increasing with any desired gradient from minimal to maximal. When, on the contrary, a quiescent ventricle is irritated, the extent of the resulting contraction has no relation whatever to the intensity of irritation. Either the stimulus is effective or it is ineffective, and in the former case the contraction curve is the same whatever the intensity of

stimulation that has provoked it. This does not mean that all cardiac contractions thus induced have the same amplitude; individual contractions of a series may differ greatly in height. Rather it is as if the amplitude of a given contraction depends upon the amount of explosive material available in the heart at a given moment; when this is fired it responds by a discharge of "all or none."

The definite application of these physiologic laws to clinical conditions would involve undesirable speculation; but, nevertheless, their consideration illuminates obscure facts of pathology. We have seen, for example, that distention of the resting heart is a distinct stimulus to its activity. When contraction is under way it frequently happens that the extent and intensity of metabolism appropriated to that systole proves inefficient to accomplish the mechanical design of contraction by emptying the ventricle of its blood; there is then an ineffective heart-beat, corresponding with an intermission of the pulse. In the long pause following, the irritable substance of the heart becomes capable of a more powerful explosion and the following systole is effective.

Tonicity of the Heart Muscle.—By "muscular tone" is meant a very slight and continuous tension exhibited by the resting tissue. If the attachment of a skeletal muscle be severed and a weighted lever be fastened to the tendon, the point of the lever will fall slightly when the motor nerve of the muscle is severed, or when the nerve-centre from which it arises is destroyed. Therefore it is clear that the tone of the skeletal muscles depends upon their connection with the nerve-centres. When a strip of heart muscle is excised and stretched by a slight weight, not only does the band of tissue exhibit the alternate contractions and relaxations corresponding to systole and diastole, but these are superimposed on much longer waves, due to variations in the tone of the muscle. The researches of Gaskell [20] indicate that the tone of the heart muscle is a very variable function, and is immediately dependent upon nutritive changes in the tissue. It apparently is specifically affected by the presence of the inorganic salts of the blood in directions in-

[20] W. H. Gaskell: "Tonicity of the Heart and Blood-Vessels," *Jour. of Physiology*, 1880, iii, 48.

dicated in a previous article. Attention may again be called to the discovery of Howell that vagus inhibition, through which cardiac tone may be experimentally abolished, is accompanied by the setting free of an excess of potassium in the heart muscle, the physiological property of potassium being, as admitted by all observers, to cause relaxation of the cardiac muscle. The walls of the healthy heart are still, under ordinary conditions, in a state of slight tonic contraction at the end of diastole, for through irritation of the vagus nerve they may be made to relax still more. The clinical student must suspect that the functional reactive power of a dilated heart is largely determined by the energy of its muscular tone.

Time Relations of the Events of the Cardiac Cycle and their Clinical Estimation.—In the clinical examination of the heart, the discrimination of the two sounds as a basis for conclusions concerning the state of the organ is of fundamental importance. Easy as is the recognition of the two heart sounds under normal conditions, it may, as a result of pathologic changes, become a matter of extreme difficulty. The cardiac impulse is, as it were, the landmark from which all cardiac events must be clinically oriented. The first sound of the heart, roughly speaking, corresponds with the apex beat, which, in turn, is due to the systolic hardening of the ventricle. The second sound is caused by tension of the semilunar valves brought about by the arterial reflux, and is heard at the end of the ventricular systole. When in doubt as to the identity of the heart tones, the clinical student must define the cardiac impulse by touch or sight, and distinguish the other events of the cycle by its aid. In a heart beating seventy-five times a minute each cardiac cycle is completed in 0.8 second, and within this period a long series of coördinated events is completed. It is hard to conceive how these relations can be sustained with a heart-rate of 150 or more per minute, although it must be observed that changes in the pulse-rate are produced chiefly at the expense of the diastolic pause, the duration of systole varying comparatively little when the pulse changes in frequency.

In the clinical study of the heart the perception of internal events may be greatly facilitated by depicting them in diagrammatic form. (Fig. 1.) Simple as the task may appear, it would probably be impossible to-day to construct a diagram to represent the relations in time

and intensity of intracardiac changes which would satisfy all investigators. Experimenters differ, for example, as to whether the curve representing the course of systolic pressure within the ventricle should have a sharp apex or be capped by a more or less flattened plateau.

The classic researches of Roy and Adami [21] seemed to demonstrate that the ventricular contraction culminates with a twitch of the papil-

FIG. 1.

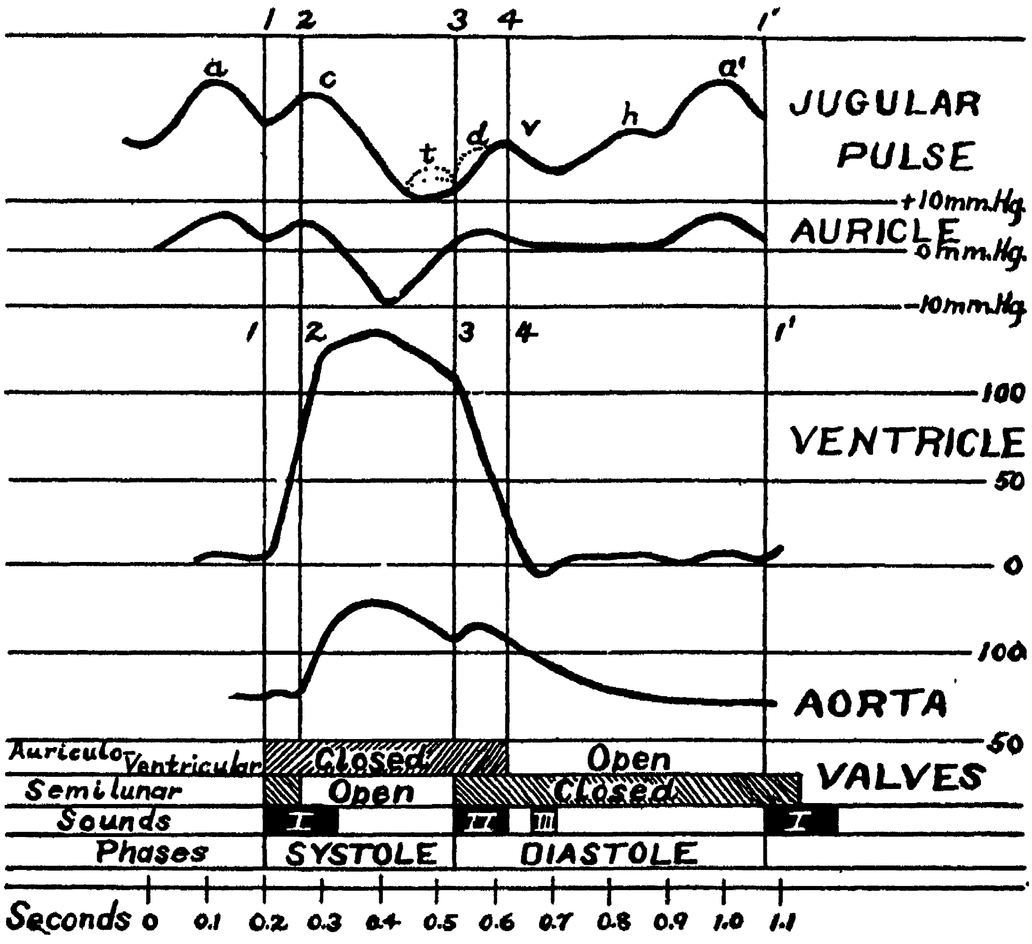

Diagram representing simultaneous pressure changes within the jugular vein, the auricle, the left ventricle, and the aorta, together with the attendant heart sounds and valve-movements.

lary muscles which gives the final effective effort in opening the semilunar valves. Many observers of late have adopted the more recent views of H. E. Hering,[22] according to which the contraction of the papillary muscles precedes that of the cardiac wall. But of much

[21] Roy and Adami: "Heart Beat and Pulse Wave," *Practitioner,* 1890.

[22] H. E. Hering, *Arch. f. d. ges. Physiol.,* 1909, cxxvi, 225 (Ref. in Hermann's *Jahresbericht ü. Physiol.*).

greater clinical importance are the conclusions which experimental observation has developed as to the place of the heart sounds in the cardiac cycle. The modern laboratory worker studies the activity of the heart by means of the impressions made by its electric action current on Einthoven's string-galvanometer. The heart sounds are registered graphically by a microphone whose resistance variations are determined by sonorous vibrations transmitted by a stethoscope applied to the chest. Fundamentally important as the electric method of investigation is, the literature shows great divergence of opinion among experts as to the meaning and time relations in the cardiac cycle of the various curves of the electrocardiogram.[23] It seems, however, to be generally admitted that the first sound of the heart either precedes the rise of intraventricular pressure in systole or even begins during the preventricular phase. According to Eyster,[24] in the normal human heart the first sound begins on the average 0.031 of a second before the *c* wave of the venous pulse, whose beginning is synchronous with the rise of intraventricular systolic tension.

According to Fahr,[25] who worked with string-galvanometer and microphone, "The first sound begins 0.02 to 0.03 second after the first indications of the action current of the ventricle." It is not proposed to attempt here a critical discussion of the literature of the subject, but certain observations familiar to the clinician seem worth recording as bearing on the laboratory findings. It is exceedingly common, namely, in stethoscopic examination of the normal heart, to apprehend the first sound to be fused with an obviously presystolic element which may take the guise of a co-called "reduplication" of the first sound or be prolonged into a veritable presystolic flutter or murmur.[26] The experienced examiner cannot but feel confident that his senses inform him correctly as to the presystolic phase of the sounds in question. Such vibrations are possibly due to flutter of the auriculoventricular valves caused by the inrush of the auricular current; they must impress the microphone and obviously fun-

[23] *Cf.* Eyster and Meek, *Arch. of Int. Med.*, 1913, xi, 204.

[24] J. A. E. Eyster: "Studies on the Venous Pulse," *Jour. Exp. Med.*, 1911, xiv, 594.

[25] Geo. Fahr: "On Simultaneous Records of the Heart Sounds and the Electrocardiogram," *Heart*, 1912, iv, 147.

[26] *Cf.* Sewall, *Amer. Jour. Med. Sci.*, 1909, cxxxviii, 10.

damentally modify the interpretation of combined phono- and electrocardiographic tracings.

Another point of some interest concerns the period initiating the second sound of the heart. To the writer, what appears to be the view of Tigerstedt [27] seems most probably correct, that the semilunar valves close first gently and that their tension and sonorous vibrations follow an instant later. This belief, however, has not been depicted in the accompanying figure. The presphygmic period of the heart, or the interval included between the beginning of ventricular contraction and the opening of the semilunar valves, "the period of rising tension" in the ventricle, might seem to vary greatly with arterial diastolic blood-pressure. But the experiments of Tigerstedt [28] show that, at least in normal rabbits, arterial pressure may undergo great changes with little or no effect on the presphygmic phase. Robinson and Draper [29] find in the normal human heart the presphygmic period to vary from 0.07 to 0.085 second, though under various pathological conditions the interval may become greater or smaller.

In compiling the data for a diagram to represent the panorama of cardiac events the writer has compared the results obtained by numerous investigators and has been compelled to dogmatically construct from them graphic tracings which seemed to him most fit to aid the comprehension of the clinical student. The curves of the venous pulse are corrected for transmission time.

The writer has been guided especially by the conclusions of Porter, [30] of Tigerstedt, [31] and of Eyster. [32]

Taking up the study of the cardiac cycle at the end of the common diastole, the first sign of activity in the heart is a short, sharp contraction of the auricles, lasting but one-tenth of a second, and which normally produces no clinical sign except a slight pulsation over the site of the internal jugular veins low in the neck. This systole of the auricles does not empty these chambers, but

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[27] C. Tigerstedt, *Skandinav. Arch. f. Physiol.*, 1913, xxix, 252.

[28] *Loc. cit.*, S. 246.

[29] Robinson and Draper, *Arch. of Int. Med.*, 1910, v, 168.

[30] W. T. Porter: "Researches on the Filling of the Heart," *Jour. of Physiol.*, 1892, xiii, 513.

[31] C. Tigerstedt, *Skandinavisch. Arch. f. Physiol.*, 1912, xxviii, 37. *Ibid.*, 1913, xxix, 234.

[32] J. A. E. Eyster, *loc. cit.;* also, "The Venous Pulse and Heart Sounds," *Wisconsin Med. Jour.*, 1911, x, 300.

shoots into the already distended ventricles a stream of blood hardly sufficient in force or amount to raise the intraventricular pressure. It is probable that an important function of the auricular stream is, by its reflux along the ventricular walls, to close tightly the auriculoventricular valves which had floated upward during the diastolic inpour. Immediately after termination of the auricular contraction the systole of the ventricles begins. At this moment the cavity of each ventricle is distended with blood, and both arterial and venous outlets are closed. The ventricular muscle suddenly hardens, the apex, which has been lying flaccid against the chest wall, rounds out and displaces the intercostal tissue in contact with it, producing cardiac impulse or "apex beat." The auriculoventricular valves remain shut throughout the contraction of the ventricle. It is important to note that the semilunar valves also remain shut during a certain proportion of the ventricular systole. They do not open until the force of contraction has raised the intraventricular pressure to exceed that in the aorta; this interval is known as the "period of rising tension" in the ventricle or as the "presphygmic period," since it antedates the sphygmographic pulse-wave corresponding to the chosen heart-beat. This interval is no doubt variable in its duration, but forms no inconsiderable part of the total period of contraction, probably forming about one-eighth to one-fourth of the duration of the complete ventricular systole, and a considerably larger proportion of the time required to empty the cavity. The period of rising tension in the ventricle has extraordinary clinical interest. This is *par excellence* the period of the cardiac cycle in which is largely settled the struggle between the power and resistance in cardiac activity.

In the figure the vertical line, 1, marks the heights of intracardiac pressures at the beginning of ventricular systole. The curve between 1 and 2 represents the rate of the rising intraventricular tension, and, though at 2 the semilunar valves are thrown open, the tension within the ventricle continues to rise as the arteries are distended; then the more or less emptied ventricle relaxes its grip, the semilunar valves close, probably gently, and are immediately brought into strong vibration by a reflux of arterial blood, giving rise to the second heart sound, marked on the sphygmographic tracing by the "dicrotic notch."

The vibrations which cause the first sound of the heart attain

their greatest intensity during the period of rising tension, and die out before the completion of ventricular systole. With the bell of his stethoscope upon the ventricular area, the student must project in imagination the panorama of the cardiac cycle. First, the apex beat is due to the contraction of the ventricles, and begins with it; during the propulsion of the apex, and for a longer or shorter portion of the period of protrusion, not only are the auriculoventricular valves closed, but the semilunar valves as well. The first sound of the heart begins simultaneously with, or slightly before, the preceding events, and the vibrations causing it probably cease when the wave of contraction has passed over the ventricle and through the papillary muscles. During all this time the blood-pressure within the ventricles has been rising, until finally, with contraction of the papillary muscles (Roy and Adami), the arterial resistance is overcome and the semilunar valves are thrown open. Shortly thereafter the first sound dies away, but the contracting ventricles continue to increase the power of their grip for a fraction of the succeeding silence. The blood pressure within the ventricle then declines until it equals that within the aorta; at this instant the semilunar valves are closed. The emptied ventricle maintains its contraction for a certain period after closure of the semilunar valves (interval between lines 3 and 4). Some authors contend that the ventricle begins to expand immediately after its cavity has been emptied. Also, the opinion is widely held that contraction of the papillary muscles initiates rather than terminates ventricular systole.

The time relations of the events of the normal cardiac cycle are more or less accurately represented in the following table: [33]

	Second.	
Systole of ventricles previous to opening of semilunar valves	0.085	
Escape of blood into aorta	0.100	
Continued contraction of emptied ventricles	0.115	
Total systole of the ventricles		0.3
Diastole of both auricle and ventricle or "passive interval"	0.400	
Systole of auricle	0.100	
Sum of the above two, making the diastole of ventricle or "pause" between second and first sound		0.5
Total cardiac cycle		0.8

[33] M. Foster: "Textbook of Physiology," 4th ed. (Macmillan), p. 154.

Neurology

INTERPRETATION OF DREAMS, BASED ON VARIOUS MOTIVES *

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WITH the advent of Freudism, the subject of dreams, their analysis and interpretation, has been brought most prominently to our attention. The Freudians have given us much information as to the meaning of dreams. But they have also told us many things which are untrue, and these statements, for purely scientific as well as for practical reasons, require correction or modification, as the case may be.

With respect to the problem of dreams a number of questions must be solved. Why do we dream? Is there any significance to dreams? What is the content of dreams? How can we understand the shifting scenes, the changing persons, the lack of sequence as to time and place, the strangeness and grotesqueness of so many dreams, the apparently disconnected, meaningless series of scenes and the bizarre, kaleidoscopic picture? How can we analyze, interpret, and explain them? What do they mean?

FREUDIAN INTERPRETATION OF DREAMS

Freud has endeavored to answer all these questions. Let us review, briefly, the essential principles in the Freudian interpretation of dreams.

1. PSYCHICAL DETERMINISM

Since nothing in the universe is fortuitous or causeless, we must conclude that the law of determinism holds true in the case of dreams. Freud, however, lays down a law of absolute and rigorous psychical determinism, in which the contention is maintained that every mental process, in dreams as in other psychical states, is the

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logical result of the past mental states or experiences of that individual; and, moreover, that dreams are always of the deepest significance in the real intimate life of the individual.

2. RÔLE OF PERIPHERAL STIMULI

Peripheral (external and somatic) stimuli are, the Freudians tell us, of no particular significance except that they may serve to initiate the dream; but the direction and content of the mental processes depend entirely on the past life-experiences—the past mental content—of the individual.

3. WISH-FULFILMENT

Dreams universally express wish-fulfilment, this term being used in a very broad sense to include all the tendencies, the yearnings, the reachings-out, the aspirations, the crying of the soul.

4. MENTAL MECHANISM OF DREAMS

The Freudians believe that dreams are the result of a compromise-formation between the buried wishes or inclinations of the individual and the so-called endopsychic censor. Certain dynamic mental trends, such as yearnings, cravings, tendencies, etc., are unacceptable to the conscious personality, and are denied expression, gratification, or fulfilment in our waking, everyday life. We therefore seek satisfaction in our dream-life. But even in our dreams the endopsychic censor, which is the inhibitory influence of consciousness, is at work, and will not permit these ideas to blossom forth in their original, unacceptable form. As a consequence there is an intrapsychic struggle between the surging desires and the repressing action of consciousness, and a compromise results whereby these thoughts are permitted to reveal themselves, but they strut across the stage in disguised, distorted, unrecognizable forms. Thus our original ideas, tendencies, etc., are staged, dramatized, or given a setting, and are presented and arranged in such a fashion that, although represented, they are quite different from our original, underlying thoughts and feelings. Consequently the dream, as we have it and as we remember it, has an entirely different meaning from that which appears on the surface.

To understand the true significance of the dream and its varying

portions, we must raise the curtain and look behind the scenes. We must pull off the mask to see what meaning or thought is represented symbolically in the dream. The true, hidden meaning of the dream is called the latent content. The actual dream, as it is presented to us, is the manifest content of the dream. In the process of transformation of the latent into the manifest content, the endopsychic censor of consciousness brings into play various mental mechanisms. Chief among these are the mechanisms of condensation, displacement, dramatization, and secondary elaboration. By "condensation" there is a fusion of the attributes from two or more different, familiar persons, objects, or scenes resulting in the production of a new, unrecognizable, composite person, object, or scene. By means of "displacement," deeply-arising and significant thoughts, persons, objects, events, or scenes are given an insignificant setting far in the background of the dream; while, on the other hand, relatively insignificant events, or persons, or objects, etc., of no real consequence to or intimacy with the dreamer, may be given very important and prominent places in the dream. "Dramatization" is the tendency present in so many dreams to theatricalize and dramatize. It is, however, by the mechanism of "secondary elaboration" that the great function of the dream is subserved. By "secondary elaboration" the distortion, transformation, and masking of the hidden, unacceptable ideas is accomplished. It is the work of "secondary elaboration," which is the product of consciousness, to guard sleep, to prevent the unconscious ideas from making their appearance in their original form. In the process of distortion all the other Freudian mechanisms are utilized to an extreme degree. In this way the mechanisms of projection, introjection, decomposition, transference, substitution, reversal, etc., are brought into activity in order to bring about as perfect and complete a transformation of the subconscious thoughts as possible.

Freudians, therefore, believe that the endopsychic censor, by repression, aided by the mechanisms mentioned above, transforms the latent content into the manifest content. The latter is, of course, full of symbolisms, frequently very far-fetched. The true meaning is always of the greatest significance to the deepest feelings of the individual.

5. LATENT CONTENT OF INFANTILE ORIGIN

Following their law of absolute psychical determinism, the Freudians next maintain that the latent content is always derived from the infantile and early childhood experiences of the individual. Later experiences, they assert, form only superficial associations, tend to group themselves about the earlier complexes or constellations, and are never of real, intimate significance to the basic psychic trends of the dreamer.

6. THE MENTAL CONTENT OF DREAMS IS GENERALLY OF AN INFANTILE SEXUAL NATURE

Not only is the basic material of infantile origin, but it is generally sexual. I am using the word sexual in the Freudian sense, thus including possible incestuous, bisexual, and polymorphous perverse sexual tendencies, both physical and psychical. This means that incestuous, bisexual, and polymorphous perverse sexual tendencies are, at least frequently, expressed symbolically in dreams, the mental mechanisms above enumerated operating to prevent these subconscious thoughts from expressing themselves in undisguised form.

We thus see that, according to the Freudians, dreams are a means of compensation for non-gratifications, disappointments, etc., in our daily lives, this desire for wish-fulfilment being satisfied by the substitutive expression in symbolic form of the unconscious complexes or constellations existing dynamically in the subconsciousness; further, if we would follow the Freudians, dreams, essentially and fundamentally, are the result of a compromise between the striving libido and the repressing action of consciousness.

From this stand-point have Freudians analyzed their dreams—and, incidentally, neuroses, psychoneuroses, psychoses, and other fields of normal and abnormal human conduct.

AUTHOR'S CONCEPTION OF DREAM INTERPRETATION

To enter into an extensive review of Freudism at this time would involve lengthy and tiresome discussion, and would lead us far afield. It is enough to limit ourselves to dreams, and to point out some of the fallacies of the Freudian school.

1. Let us first consider the question of psychical determinism.

All must admit that for every result or effect there must be a logical and efficient antecedent cause. This law is universal. Consequently, in the world of the mind, we must agree that there is a definite reason for every mental process, for every psychic state in our lives—and hence, also, in our dreams. So far I agree with the Freudians. But—and this is an important point—this does not mean that the antecedent causative mental state or states necessarily existed primarily in our present life histories. On the other hand, we must include our entire phylogenetic and ontogenetic histories. In other words, we begin life with inherited instincts about which, as a basis, all future mental constellations are built. It is our instincts, therefore, plus our infantile, childhood, adult, everyday, and pre-sleeping experiences and mental processes which determine the content and direction of the mental processes of our dreams.

2. Thence, we are led to the further assertion that peripheral, external, and somatic stimuli of normal or abnormal nature may play quite a rôle in this direction, not only in initiating the dream but in directing the trend and content of the mental processes.

At this point permit me briefly to discuss the question of human instincts.

We know that by heredity man is gifted with certain instincts, traits, or unit-characters. As has been so aptly stated by Thorndike, man's mental life is everywhere rooted in instincts. These instincts are the inherited stuff whereof the mind of man is made. They are the raw materials from which the adult is moulded. They have been selected in the course of evolution through phylogeny and ontogeny. In the process of adaptation in the struggle for existence, with the survival of the fittest, certain qualities have been selected for survival and transmission in a heightened degree. The need of certain qualities depends on the environment, the training, the education, the standards, the opportunities, the gratifications and disappointments, the need for struggle along certain lines in preference to others, etc. It has so happened that the intensity or potentiality of certain instincts differs in different individuals, especially in those living in different parts of the world. As a result we have inherent racial make-ups of more or less characteristic types. Some instincts are much older phylogenetically than others. The older instincts are more basic, more fundamental, more fixed and rigid, less

tion, on the one hand, we have acquired biologically such instincts as the demand for food, shelter, and clothing, the instincts of play, of work, of fatigue, of sleep, of defence, etc. Based on our instinct of sex-gratification, on the other hand, we have our sexual instincts. It is worthy of mention that the desire for sex-gratification is but a special application of the general demand for self-preservation. Now, dependent on both these fundamental motives, there have been developed various other instincts of the greatest importance to advancing civilization and humanity. These include the marital, the paternal and the maternal, the filial, the social, the moral, and the altruistic instincts. These tendencies exist in all of us in varying degree. They are the mental trends which direct us. They are the driving forces in the difficult task called daily life. They modify our feelings, our loves, and our hates, our desires and our ambitions. In short, they determine our conduct. It is the function of intellect, of reasoning, of judgment and critique to control and direct these impulsive yearnings and strivings so that they will promote the best interests of ourselves, of those dependent on us, and of society in general.

It is these instincts which guide our conduct at all times, whether waking or sleeping. They are, therefore, at the basis of all the mental processes in our dreams.

These instincts are appealed to more or less, are moulded and shaped to express themselves in devious ways, from the moment of birth. The environmental influences do the moulding and the carving. The earliest or pre-pubescent experiences are naturally most potent. But, as tendencies or instincts are prone to appear in the order of their evolutionary acquirement, those which are relatively late in manifesting themselves, though greatly moulded by earlier infantile and childhood experiences, may be much influenced by subsequent experiences. This influence is especially marked if the instincts in question appeared early but were little appealed to one way or the other.

We must conclude, for this reason, that not only early but also later experiences may form complexes of decided and intimate significance to the deepest trends of the individual. It is a case of constant appeal to our fundamental instincts, and the response of, or effect upon, the particular instinct appealed to depends on the relative development or intensity of all the other instincts, and the degree of

influence already exerted upon the expression of this instinct in a particular direction.

Now, then, we can understand how, during sleep, certain ideas resulting from association, and also from peripheral stimuli, both somatic and external, may appeal directly to certain instincts, and absolutely determine the direction and content of the mental processes of the dream. Peculiar sensations in the skin and viscera, or unfamiliar auditory impressions, may give rise to various fears dependent on the instinct of self-preservation. Dyspnœa occurring in cardiovascular disease may lead to thoughts of impending death, of choking, hanging, etc. Adenoids may give rise to night terrors.

Of course, all the past experiences and thoughts of the sleeper,—his mental make-up,—play their rôles in interpreting and weaving into the dream his particular sensory experience. Certain sensory experiences may, however, absolutely determine the general content of the dream by arousing a reaction expressed by a particular instinct. For instance, a child who has fallen asleep on the couch may be carried to bed by his mother. The sleeping child may have a dim consciousness of being moved. This may at once lead to a dream about burglary, kidnapping, tortures, fire, etc. True, the past experiences are the material wherewith this dream is clothed, but it must be remembered that many of these thoughts are more or less common to all of us. The real foundation of this dream is the activity of the motive of self-preservation, which has been excited by a certain sensory experience.

3. Do all dreams express wish-fulfilment? To me this term seems inadequate. "Wish-fulfilment" does not cover all our fears, and instead of it I would use the term "self-expression." Every one of us, every moment of his life, is seeking self-expression. It is the instinctive tendency toward gratification of the personal tastes and feelings as immediately as possible, and frequently at any cost. Based on our desire for self-expression are built up all our loves and our hates, our wishes and our fears, our joys and our sorrows, our satisfactions and our regrets, our gratifications and our disappointments. Although fundamentally the manner of our self-expression is more or less uniform, yet one seeks happiness by expressing his individuality more in one direction than in another until a certain mode of self-expression may be the be-all and the end-all of existence

for that particular individual. It is only by self-expression that we gain happiness, which is the final goal of every one of us, each in his own way. Wish-fulfilment, therefore, should be replaced by self-expression.

4. Now we come to the Freudian conception of the mental mechanisms of dreams and the process of dream-making. This includes the method of compromise-formation between the endopsychic censor and the desire for wish-fulfilment, with the employment of the various mental mechanisms, the relation of latent to manifest content, the intra-psychic struggle, and the symbolism employed as disguise.

This theory is, I must admit, very plausible and fascinating,—so fascinating, indeed, and so interesting that we would like to believe in it. It assumes man to be a wonderful, powerful, complex individual, yet withal irresponsible, helpless, and a mystery to himself. He is more to be pitied than envied; for, if the Freudian theory be correct, man does not at all understand or know himself.

Personally, however, from my study of the meaning of dreams, I cannot accept the Freudian hypothesis. In support of my viewpoint, I need only refer you to the study of dreams as analyzed by Freudians, and then request you to analyze some of your own dreams along Freudian lines, also according to the concept outlined in this paper.

Let me say at once that I do not believe in the law of psychophysical parallelism which would separate the mental and physical, and would have them accompany each other, side by side, though independent of each other, like a man and his shadow. Our reactions are mainly (and apparently purely) mental, or mainly (and apparently purely) physical. Between these two extremes lie a continuous series of various combinations of the mental and physical. Now, we perform instinctively various actions and possess instinctive feelings. The James-Lange theory of the emotions asserts that our emotional states can be accounted for by preceding physical states from which they arose. The proper attitude, however, is to look upon the individual as a biological unit. Man, in his adaptations, reacts biologically, so that certain mental reactive states have certain correlated physical accompaniments. For example, when, owing to the instinct of self-preservation, we react by fear, we find that, besides

the characteristic mental state, there are the physical correlates of tremor, pallor, rapid heart, perspiration, etc.

How is this related to the subject of dreams? Viewed from the biological and evolutionary stand-point, sleep is a complex instinctive tendency. To a certain extent, we can control it, but the control is very limited. Whether we will or no, we must sleep. Sleep is a biological reaction of adaptation to prevent too great fatigue and exhaustion, and to permit of rest and repair. Sleep, then, being a biologic, instinctive, adaptative defence-reaction to the possibility of fatigue, is thus necessary for self-preservation. We may even resort to it purposely and consciously as a temporary relief from life's daily round of toil, struggle, trouble, and worry.

Sleep, then, is a state of the mind and body considerably lower in the scale of evolution than is our normal waking state. Accompanying sleep, which, of course, primarily depends on physico-chemical and physiological changes in the nervous system, there is an associated, correlated mental state or degree of consciousness. The sounder the sleep, the less active is consciousness, likewise the degree of awareness and the mental processes conditioned thereby. The less sound the sleep the more active is consciousness, with its accompanying mental processes and degree of awareness. It is obvious that, on the mental side, it is wholly a question of degree of consciousness. With respect to the varying degrees of consciousness in sleep or in other psychic states, we can lay down this general law: The lower the degree of consciousness, the lower is the reason, the selective judgment, and the critique of the individual, the lower is the degree of awareness, the greater is the suggestibility, the freer the rein to instinctive tendencies and individual desires, the less orderly, guided, and logical the mental processes, and the less apt is one to remember the content and trend of these processes. Since, in sleep, the play on our instincts, our wishes, our fears, etc., is free, misinterpretations and inadequate reactions may occur. Association and flight of ideas may be very marked. Slight resemblances may lead to a change in the content or trend of the dream. Consequently, the mental processes in dreams are what one might expect for that grade of consciousness, that grade in evolution.

Although sleep is a biologic defence to fatigue, the mental processes at work in dreams are not, as Freudians believe, weapons of

defence against the too frank expression of our repressed wishes. It is the lowered state of conscious activity which is the defence. The content and direction of the mental processes is the same; but their orderliness, their logicalness, their selection, their interrelation, and their control are lessened. In waking life our consciousness works with the mental content already a part of us, with the materials about us, and with the stimuli which we are constantly receiving. So in our dreams our then state of consciousness, whatever it be, employs the material at hand—our mental content plus the various somatic and external stimuli. One or the other of these may be sufficiently intense to dominate the trend and content of the dream. Or neither of them may be of sufficient intensity or significance to the individual to exert such influence. Association and flight of ideas may, in such cases, be very superficial, rapid, and free, and the trend and content of the mental processes may undergo a rapid and continuous succession of changes, due to internal associations or in reaction to peripheral stimuli. Critical selection, intelligent judgment, proper evaluation, and correct interpretation are far below par. Shifting scenes, changing persons, incongruous occurrences, dramatizations, misinterpretations, symbolisms, etc., may cavort over the stage with the greatest freedom. The mental mechanisms, all of which are actively employed in our normal waking life with its clear consciousness, are permitted to run riot in our dreams with their states of lowered consciousness. Fantasy and association of thought prevail. Creative thinking is absent or slight, since that is the function of clear consciousness, and is exercise which is fatiguing to the individual, and against which sleep, with its correlated state of dim awareness, is a biologic defence.

This, it seems to me, makes it quite plain that fundamentally dreams are not the result of an intrapsychic struggle between desire and repression.

Another thought worthy of serious consideration is this: Much of the kaleidoscopic quality of a dream, its crazy-quilt character, is due to the fact that there is a tendency to retardation of some scenes, ideas, persons, words, etc., and anticipation of others. Consequently, in rapid association and flight of ideas, great admixture, reversals, fusions, may follow. Many of these may be significant in that the material woven into the dream may be of a nature or content of

decided intimacy to the dreamer. On the other hand, there may be an indiscriminate employment of the psychic material in a helter-skelter fashion, without a sense of proportions, with a levelling of ideas, insignificant events being given a most prominent position, important events being assigned a most insignificant place, etc.—all without special design or purpose on the part of the dreamer. Of course, in the ultimate analysis, all mental content can be shown to be centred about our instincts and our habits, which latter, in turn, are themselves moulded by our instincts. However, although all physical and psychical activity can be shown to be biologically related to one or the other of our instincts, we cannot maintain that it was because of this significance that we consciously and purposively brought this or that process into activity. The child's hand instinctively reaches forth to grasp whatever it can lay hold of; it may also desire to obtain possession of certain definite articles. So also in dreams the mental material at hand may be used indiscriminately or somewhat selectively.

This idea of retardation and anticipation of ideas, with or without order or criticism, is the true explanation of most of the psychopathological acts of everyday life which occur in states of inattention and distraction. The conclusion is that the law of probability or chance plays a great rôle in dream-content and dream-formation.

Again, since consciousness is lowered, the reaction is naïve, inadequate, not relatively compensatory, illogical, and disproportionate. It is excessive in some cases, subnormal in others. Thus, without proper intellectual evaluation and control, the emotions may run riot.

Why are dreams mainly reminiscences? In the state of lowered consciousness which exists in dreams, creative activity is slight or absent. When creative activity is brought into play it is relatively uncritical, the action is poor, the problem is solved too easily and not in accordance with the facts of the hard, cold, workaday world. Either extreme, catastrophes and disappointments, or full gratification, may follow. As a result, the solutions of the problems may be either in entire harmony or in complete discordance with our wishes or our fears. In most dreams, however, creative thought is practically *nil*. This means that the mind must work with the material already stored within and with the sensory experiences already re-

ceived. In other words, any of the mental content, any of the mental material which has been incorporated in the past may be employed. We find that infantile experiences, experiences of childhood, later experiences, including those of the very recent past, such as the thoughts of the day before and of the pre-sleeping state, may one or all play a prominent part in the dream. Thus the mental material of dreams is frequently direct reminiscence or of kindred nature, or it expresses the wishes and fears which are integral portions of our individual mental lives or are the expression of our common instinctive tendencies.

5. We must agree, therefore, in the fallacy of the Freudian contention that dreams are essentially reminiscences of infantile tendencies and experiences. If the idea that it is the instincts which are fundamental is correct—and of this there can be no doubt—then we must rightly conclude that the mental content of dreams may be not only of infantile origin, but of any time thereafter, up to the moment of the dream. And, further, the mental processes of dreams, though, like all other activities, mental or physical, biologically significant in relation to our instincts, may, however, be of no particular significance to the dreamer. Some dreams are of universal human significance. Others are of decided individual consequence. Different portions of a dream may be related to different instincts.

6. It is evident that sexuality is most certainly not the basis of all or most dreams. I am using the term sexual in the broadest possible sense, including the Freudian view-point of infantile sexuality (that is, the incestuous, bisexual, polymorphous perverse sexual tendencies, physical and psychical). Whether this or that instinct is at the root of a certain dream or portion of a dream depends on the mental make-up of the individual—on the sexual make-up and experiences of the individual and on his other tendencies and lines of interest and expression. Some dreams or portions of dreams depend directly on sexuality. But dreams may also depend on any of our other instincts, especially the instinct of self-preservation. Moreover, in the vast majority of dreams, even when dreams are sexual in nature, the infantile incestuous, bisexual, and polymorphous perverse sexual tendencies play little, if any, rôle in dream-content and dream-formation.

Even if Freud and his school limited their ideas to the dreams of

neurotic persons, their contention would be without foundation, for this reason: Neurotics differ from the rest of humanity in degree only —in degree of control over the emotions, in degree of stability of the nervous system, in degree of adaptability to varying and inimical environmental conditions. What is true, therefore, of neurotics is true, but in less degree, of all normal individuals. Consequently, if all the dreams of neurotics depend on sexuality, then it must follow, as the night the day, that all dreams, in normal as well as in neurotic individuals, must likewise be dependent on sexuality.

I wonder how many Freudians who believe that all or most dreams have their basic origin in sexuality appreciate the fact that, if their assertion be true, then, since the difference between dreams, hypnotism, hypnagogic states, hypnoidal states, states of revery, day-dreaming, castle- and air-building, our idealistic dreaming and all our normal waking thoughts,—since the difference between all of these states is one of degree,—what is a fixed law for dreams applies with equal weight to all of these other mental states. Or, to put it more plainly, if the content of dreams is of sexual origin, then the content of all mental states, normal or abnormal, is of sexual origin. As a matter of fact, the Freudians, having laid down the dictum that all psychoneuroses and neuroses have a sexual etiology, must, if they extend this law to include all normal mental states (which differ from abnormal mental states quantitatively only), believe that all mental processes take their root of origin in sexuality.

There is one view-point from which we can arrive at the conclusion that sexuality is the foundation-spring of all dreams,—and that means all mental processes, all human activities,—that view-point, stated briefly, may be expressed in this fashion: All activity or conduct is useful or harmful, desirable or undesirable, agreeable or unpleasant, to one or the other of us. Since an individual, in the case of man, who is bisexual, is of one or the other sex, and this or that activity or mental state is of significance to him or her, as the case may be, consequently that activity or mental state is of sexual significance. Following this line of argument, anything which is of possible significance to any one of us is of sexual significance. And if this be so, let me then add that every atom and every spark of energy existing anywhere in the universe to-day is sexually signifi-

cant, for the simple but important reason that everything occurring in the universe is of some importance and concern to man.

Such reasoning, you will agree, is fallacious; but, strange to say, the Freudian idea of narcissism or self-love to explain the delusions of self-esteem or the exaggerated ego in paranoia seems to me to indicate that such is their stand-point.

I may say, in parenthesis, that, from the stand-point of a piece of stone, everything has a "stony" significance. The rain, the sun, the earth, the lightning, may all have some effect upon it—and consequently (?) must depend upon it.

7. Why do we awaken when dreams are disagreeable or shocking? Freudians maintain that the subconscious wishes are endeavoring to make their appearance in a positively unacceptable form, and, in order to prevent this, the endopsychic censor rouses the sleeper to full waking consciousness. An analysis of one's own dreams at once proves that this theory is not well-grounded. When a dream is very shocking or very disagreeable awakening comes as a biological defence. In states of fear and allied states it is the instinct of self-preservation which is strongly appealed to. Dreams which are most vivid and best remembered occur in a state of light sleep, just as we are dropping off into, or just coming out of, sound sleep. The dream-thoughts may be so strange and bizarre that our sense of criticism is whipped into activity, or the presentation is so vivid and dangerous, or certain instincts are so strongly appealed to, that our sense of awareness is stirred up, we are roused by the danger, and we wake up. Why do we awaken? To prevent our ideas from coming forth in naked dress, in forms unacceptable to the conscious personality? As a purely psychologic defence? No. It is rather to protect ourselves from the experiences through which we were passing in the dream. It is the dream itself which caused us to react in biologic defence. Any one of our instincts may be the driving force.

8. Why do we forget dreams so quickly? Freudians maintain that the forgetting of dreams is purposive, is due to the continued action of the endopsychic censor which, by secondary elaboration, is the agent of the dream-making, and whose activity does not cease even in the waking state. The dream, the Freudians tell us, is forgotten because of a psychologic defence, since the ideas are disagreeable or unacceptable to the conscious personality. Some Freudians

even believe that dreams are selectively forgotten, so that the most significant portions may be purposively forgotten or rather repressed, while the least important portions may be remembered longest and best. Here also I must take issue with the Freudians. Forgetting of dreams is a defence. But it is usually a biological and physiological, and not a psychological, defence. Bad dreams, like all depressing thoughts and states, had best be forgotten and banished, since they are harmful to the individual. Pleasant dreams it would frequently be advantageous to remember because of the stimulating mental effect they may have on us during our waking state. Aside from this, the remembering of dreams is of no biologic utility. Dreams may as well be forgotten for all the good they will be to the dreamer in his waking life, no matter how closely related his dream thoughts may have been to his instincts, his basic wishes, and fears. Consequently there is the physiological tendency to forget dreams.

Another reason why we do not remember dreams is the fact that in sleep our state of awareness or consciousness is lowered, and hence impressions are not as accurately nor as clearly perceived as in the waking state. We all know how frequently in our dreams we have only a hazy consciousness of what is going on. What we were never fully aware of in our dreams, we cannot, in our more conscious moments, completely recall or clearly remember. Much of the so-called amnesia for dreams, like much of the amnesia for experiences of infancy and early childhood, is not amnesia at all, since there never was a truly definite appreciation of what was occurring.

Still another factor contributing no small share to the forgetting of dreams is that, practically so soon as we awake, we are at once engrossed with new problems—we rush into our clothes, hurry over dressing, eat breakfast, dash off for the day's work. The natural result is that the dream thoughts are buried, physiologically, under the burden of the intensive present—and this without any conscious effort at repression.

Of course, in some instances, when dreams of a very disagreeable nature tend to recur to mind, we may make conscious efforts to suppress the disturbing thoughts.

We are most apt to remember dreams which are very pleasant or very disagreeable, and have made a strong impression upon us. Moreover, we are more apt to remember a dream if it occurred in a state of

light sleep, and if it was coördinated and logical. We remember best the most vivid or the last portion of the dream. Very frequently we forget the initial stimulus or ideas, or the earlier sleeping thoughts which led up to the dream or portion of the dream which we can recall. The greater and the more direct the appeal to our basic instincts and to our most highly developed motives, the better do we recall the dream. Furthermore, dreams which are reviewed while still lying in bed, or as soon thereafter as possible, should be most vividly recalled.

9. The reason for the increased suggestibility and tendency to independent automatic activity of the lower nerve-centres or functions in certain dream states is that consciousness or awareness is lowered, there is a return to a biologically lower scale of consciousness and activity in which suggestibility is marked, and ideas may control the body. The ultimate cause of this we do not know—any more than we know why life came upon the earth, or the answer to similar questions of ultimate origin.

Dreams, therefore, are not, as Freudians would have it, the neuroses of the healthy, nor are they, as Freud says of the neuroses, the negative of sexual perversions. This means to say that neuroses are not the negative of sexual perversions.

The dreams of the child are more direct than those of the adult, not because they are less bound by convention and the endopsychic censor, but because their experiences in life are more simple and less numerous, their cares, worries, trials, tribulations, and responsibilities are less intense, their mental faculties are less well developed, their associations are not so extensive. What applies to the nocturnal dreams of children applies in like manner to their day-dreams, their play, and their methods of recreation. It is as definitely applicable to our adult reveries and fantasies, our life-dreams, our ambitions, our aspirations. All effort is a search for happiness, a struggle for self-expression, based on our various instincts, especially the instincts of self-preservation and sex-gratification.

10. To what extent can dreams be analyzed? How can they best be analyzed?

In answer to the first query I will say that, as all of us know, some dreams can be analyzed; others cannot. The analysis of a dream is possible only if the dream is vividly, accurately, and se-

quentially recalled, and if the underlying, inciting ideas and experiences can be brought into association with the dream thoughts, of which they give the explanation.

With respect to the second question, I may say that ordinary introspection by the dreamer is the normal, usual, and probably best method. The Freudians, as you know, analyze dreams by the free and word-association tests, in conjunction with introspection.

Some Freudians tell us it may take weeks and months to analyze a dream. I will admit that it may take some time to analyze a certain particular dream or a special portion of a dream of unusual significance. I have, as yet, had no cases of this kind. But almost all dreams which can possibly be analyzed practically depend for their analysis on the following conditions:

1. Immediate recalling and recording of the dream, while lying in bed or as soon thereafter as possible.

2. Immediate analysis of the dream by introspection and recalling of thoughts or experiences just preceding the dream in question, of the preceding day, and of the recent and even remote past.

3. Association tests, if of any value, must, in most cases, be applied at once. I feel, however, that no better results can be obtained by association tests than by introspection.

4. The analysis of the dream depends entirely on the dreamer.

5. The interpretation of the underlying instincts or motives and the interrelation of different portions of the dream can be best appreciated by one experienced in dream analysis; but after a period of training, any intelligent person can analyze his own dreams, providing, of course, the dream thoughts and the associated significance are recalled.

Analysis of dreams is interesting for a number of reasons:

1. For the sake of pure science—a search for truth and knowledge.

2. To clear the atmosphere of certain superstitions concerning the significance of dreams.

3. In certain nervous and mental states they may be important aids in ascertaining the underlying psychic cause, hence in psychotherapy.

4. An understanding of the mental mechanisms of dreams will put us in a fair way the better to understand the psychopathologic

acts of everyday life, psychoneuroses, psychoses, and other normal and abnormal mental states.

In conclusion I wish to state that the primary and original cause of my interest in dreams was a desire to confirm or disprove the Freudian conception of dreams. In my own case we see the activity of the motive of investigation as the foundation-spring of my conduct. And let us not forget that the spirit of investigation was originally dependent on the instinct of self-preservation.[1]

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[1] In this paper, in order not to interfere with the continuity and trend of thought and to present the essential facts more concisely and directly, the author purposely omitted the inclusion of illustrative dreams analyzed and interpreted according to his conception as outlined in this paper. For such application of the ideas here elaborated the reader is referred to the following two articles by the writer: "Analysis and Interpretation of Dreams Based on Various Motives," *Journal of Abnormal Psychology*, vol. viii, No. 2, June–July, 1913; and "A Contribution to the Analysis and Interpretation of Dreams Based on the Motive of Self-Preservation," to appear in *American Journal of Insanity*.

NEUROTIC DISCOMFORT AND THE LAW OF AVALANCHE *

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ONE of the most interesting of the symptoms that nervous patients complain of on coming to your office, though at the same time the most obstinate to treat, is discomfort. They have pains, or at least what they call pains, and aches in certain muscles, in the neighborhood of certain joints, in the head, in the thorax, in the abdomen, almost anywhere and everywhere, and they feel assured if they could but be rid of these pains or aches or discomforts they would be quite well. When their feelings are carefully analyzed they are quite ready to confess—after a time, at least—that the pains are not acute, and the aches not severe, but they are very real, and so disturb them that life becomes miserable, even nutrition is often interfered with, sleep is broken, and their physical condition deteriorates. As a rule, they dread some serious developments from the discomfort, and this affects the appetite, lessens their eating, often their exercise, keeps them in the house, and, therefore, readily sets in motion a vicious circle of pathological causes and effects which tends to aggravate their condition.

The most interesting chapter that I know of in the history of medicine is that which relates the cure of these conditions, and the examples of such "cures" are numerous. As a matter of fact, the

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* A lecture delivered at Fordham University School of Medicine in the course on nervous diseases.

The law of avalanche is a term employed by Ramon y Cajal to indicate the mode by which single simple sensations at the periphery of the body may be multiplied into an avalanche of sensations within the brain. In my translation of a lecture of his for INTERNATIONAL CLINICS, vol. ii, Series 11, Prof. Ramon y Cajal said: "Impressions are made upon single cells at the periphery. As the result of the disturbance of the single cell, an ever-increasing number of cells are affected as the nervous impulse travels toward the nerve-centre. Finally the nervous

reputation of nearly every healer in the history of medicine, of most of the many systems of treatment which have come and gone in therapeutic history, and of the new drugs which have cured for a time and then been relegated to the lumber room of disused remedies, has been won by the "*cure*" of conditions involving pains, aches, and discomforts of various kinds. Ordinarily it is at once assumed that the relief of pain must represent physical factors, and must be due to certain definite changes produced in the tissues by the mode of treatment. Analysis of the history of such cures, in which many thousands of sufferers from various ills have at various times been relieved, convinces one that the main feature of the "cure" has always been a deep impression produced upon the mind of the sufferer, and that the physical action of the means employed has always been either insignificant or very trivial as compared with the ultimate results. This is so surprising to many people that when first heard they can scarcely credit it, yet it is abundantly illustrated by the history of medicine, and I know nothing that is more interesting nor, at the same time, more valuable and suggestive for the physician than a review of these episodes.

Here, in America, when the notorious Elisha Perkins began his great work of curing nearly all of the ills that flesh is heir to, besides a few others, his success was particularly marked among people affected with pains and aches of various kinds, especially among old people in whom pains and aches multiply in the course of a long life, and make them miserable and objects of sympathy in their declining years. Perkins had become very much interested, as had most of the world of his day, in Galvani's discovery of the fact that if two different kinds of metals be placed in contact, and their ends permitted to touch the nerves and muscle of a frog's leg, twitchings would take place. This was supposed by many scientists of the time,

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impulses reach the brain and are spread over a considerable group of pyramidal cells in the cortex." In his paragraphs on attention he says that if conscious attention is paid to the sensation a great many other cells throughout the brain become affected by it. It may be that every cell which subtends consciousness will at a given moment of intense attention be tingling from a single sensation. If it is unpleasant, the unpleasantness is multiplied to a very serious degree. The "law of avalanche" has a very large place in disturbing the lives of those people who have much time on their hands to think about themselves and who are always solicitous less some serious condition should be developing.

led by Galvani himself, to indicate some wonderful connection between electricity and vital force. Interest in electricity and its possibilities in medicine was just awakening. There had been much discussion, *pro* and *con*, first between Galvani and Volta, and then among the scientists of the world who were interested in things electrical, as to the real significance of these frog twitchings. The result was that many people were anticipating some wonderful curative development along this line, and Elisha Perkins, of Norwich, Connecticut, made his *discovery*, or, as he preferred to call it, *invention*, just at the psychological moment.

He took two pieces of metal of rather intricate composition—according to his application for a patent they contained even some gold and silver—about the size of a lead-pencil and tapering gradually to a somewhat blunt point, and holding these in contact at their thicker ends he *stroked* patients with them. He called the instruments tractors, and his method of treatment tractoration, while his system of therapeutics came to be known as tractorianism. A large number of people soon came to be tractorated. Long, mouth-filling names are always important for these remedies. Perkins cured his patient of all sorts of affections, *particularly such as involved discomfort*. He stroked joints and muscles, and people walked without pain; he stroked their heads and their headaches disappeared; he stroked their feet and they could walk better; he stroked their abdomens and all sorts of "misery" therein disappeared. Not every one was cured, but many people were, and they told the story of their wonderful cures to others, as cured patients always do—remember, this is how your practice will grow—and before long crowds flocked to take advantage of this new discovery. The physicians of Norwich met, and decided that there was nothing in Dr. Perkins's discovery. They were right in that decision. He was expelled from the local medical society, but this he used as an advertisement to show that the physicians were jealous of him, and that his discovery was so important that they wanted to prevent its use because it would literally cure all ills and put them out of business. This is what the quacks have said in every generation, even our own, and in every generation, above all our own, multitudes have believed them, and sympathized with them because they were persecuted. For many of them this

was the very best thing that could happen to them—that is, from a monetary standpoint.

After making a success in Connecticut, Perkins considered the field too limited, and went to Europe. First he settled down in Copenhagen. Just why American physicians with a questionable discovery to be exploited should choose to go to Copenhagen is not clear, but Perkins had at least as much success as Dr. Cook. He cured a member of the legislative body of Denmark, and soon the nobility flocked to him, and he made many cures. Thence he went to London, and the same story was repeated. Some of the elder nobility were cured of long-standing pains and aches, and before long people were flocking to Perkins to be *cured*. He took out a patent on his tractors, and published the certificate of the patent office as the Government acknowledgment of his great scientific invention. He presented a pair of his tractors to the Royal Institution, and published their official acknowledgment as a recognition of the scientific value of his discovery. I do not think that any modern exploiter or promoter of a cure had, in our expressive American phrase, "anything on" Elisha Perkins, from the Wooden Nutmeg State. A Perkinean institution was founded in London, and "cures" *galore* were reported. They continued to happen, in spite of the fact that some doctors in London used wooden tractors painted to resemble metal, got just as good results, and told their story to the public. You should read Perkins's indignant protest at this. Better still, read the whole amusing story in Oliver Wendell Holmes's "Medical Essays."

Poor Perkins himself, I am quite sure, believed in his discovery, for after his great success in London he came home to America, anticipating still greater success here, and, of course, might have obtained it after his European triumph, for what succeeds abroad takes here, a prophet is never a prophet at home, but he was overconfident. An epidemic of smallpox,—I think it was smallpox,—was raging in Philadelphia. Perkins was quite certain that if his tractors would cure diseases they would also prevent them. He went to Philadelphia to demonstrate the prophylactic power of his tractors over smallpox, but, alas for poor humanity, he took the disease, and died of it! Perkinism, or Tractorianism, died with him.

And this episode is not exceptional in medical history. On the

contrary, it is quite the usual story. Practically every generation has seen such healers and such cures, *particularly for pain, discomfort, aches, and ill-feelings.* In the seventeenth century, when, after the execution of King Charles I, Oliver Cromwell refused to continue the practice of the English kings of touching people for various ills, and curing many of them, an Irish adventurer, named Greatreakes, announced that he had been divinely inspired by a thrice-repeated dream in which he was told to go, and touch, and cure the ailing. He announced that the power had been given him, and sure enough, at his touch the ills of people dropped from them. Like Perkins, he stroked the part affected, and immediately they felt his life-giving power and began to improve. After they had been touched a few times most of them were well. People flocked to him from everywhere, and were cured. Some one has said in the modern term that he "*touched*" them very effectually. The English kings had given to each of the patients who came to be touched by them a piece of money and sent them on their way rejoicing. Greatreakes required that those who came to him should give him a piece of money, usually a sovereign, and this was the real *royal touch.*

Do not think that such incidents belong only to distant times when people were much more ignorant than now, and that such credulity would be impossible in our time when the diffusion of knowledge and the popularizing of education have supposedly made people less susceptible to such superstition and less credulous. Dowie claimed that he had cured 50,000 people in the course of a few years. I believe that something like 200,000 people went to him for treatment in the course of his career, and he was sure that he had *cured* most of them and benefited all. Remember that the majority of them had what is supposed in our time to be the essential index of sanity, the power to make money. Others need not have applied. Less than twenty years ago, poor, half-witted Schlatter cured a large number of people who came to him of pains and aches of all kinds, simply because he announced that he had a mission from on high to make such cures. Dowie declared that he was Elijah returned to earth. I can not now recall who Schlatter claimed to be, but the cures were simply the result of his announcement of his mission and of people's confidence in him.

Many other examples might readily be cited. Mesmer effected

many cures. Although he did not use what we call hypnotism, he did produce a certain dreamy state in which people felt their pains and aches drop from them. When hypnotism developed, that, too, made cures, particularly of discomfort of body and of mind that had long been a source of worry to people, and had disturbed their nutrition in various ways. When Liebault called Bernheim's attention to hypnotism at Nancy it was because of the cure of an obstinate case of sciatica for which Bernheim could do nothing.

During the nineteenth century we have had in America a series of these psychic manifestations resulting in cures. There was a school of psychology at Poughkeepsie that became famous because of the "cures" effected by its disciples, especially by the master of the school. His system attracted so much attention that he was asked to deliver an address before the United States Senate, and we came very near having this system of "psychology" in therapeutics imposed upon us by law. Since then we have had Metaphysical Healing, New Thought, and other things with new-fangled names as healing systems.

Anything which, like Perkins's tractors, is supposed to herald some new discovery in science particularly appeals to people as a cure. Every advance in science, such as Galvani's discovery with regard to the frog, has been adapted in some form to medicine, and has done much to relieve people. When the Leyden jar was invented it was carried about Europe, partly as a new and interesting invention, but also in order to cure people of their pains and aches. It is amusing now to read of the wonders worked in this respect by little Leyden jars that we regard merely as toys. Not only did the jar cure people, but absolute proof of its power over physiological processes was found in the fact that when used to excess it produced certain affections as well as cured them when used properly. At about the middle of the eighteenth century, if three charges from the little Leyden jars were given to women, they suffered from headache, or nausea and vomiting, or prostration so severe as to require stimulants. Priestley, the discoverer of oxygen, has related this story in his history of electricity. Of course, the Leyden jar produced no such effects for good or ill, but it did produce an effect on the minds of the patients, this was transmitted to their bodies, and the result was the same in the end.

When, in the nineteenth century, the effect of light upon the silver salts was discovered, and men were experimenting with photography, it was noted that the blue rays of light were more active than the rest of the spectrum. Accordingly, for some reason, it was concluded that these rays must also produce good effects upon people suffering from various ills. It is said that a glass factory had by mistake manufactured much more blue glass than it could dispose of. The manufacturers were in despair; then it was suggested that they might start a newspaper story that blue glass cured all sorts of pains and aches. Most of the newspapers took it up, and before long the factory not only disposed of what blue glass it had, but was obliged to manufacture much more. Then nearly every glass factory in the country began making blue glass. I remember turning over in the garret of our country home not long ago some framed panes of blue glass which used to be hung in the windows of the house, and underneath which some of the elders of the family, suffering from the chronic pains and aches that were then called rheumatism and are still called rheumatism by many, used to sit for the relief of their pains and aches. After a time the fad passed away, but there are still people who believe that real physical benefit was derived from it, or it would not have been used by so many people.

Electricity has been the fruitful source of many of these therapeutic fads. Each new development in electricity has been followed by wonderful curative results. After a time, however, the particular efficacy of the new mode of treatment either vanishes or proves to be non-existent, apparently because people have grown accustomed to it, and it no longer has the effect of novelty. In our own time there are many electrical modes of treatment that are not used by physicians. I suppose that you have often seen the electrical belts that some people wear and that have not a spark of any kind of electricity in them. I discovered the other day that an old patient of mine was wearing what he called "electric insoles." He was suffering from flat-foot, and was quite sure that for a time his discomfort had been greatly relieved by insoles, one of copper and the other of zinc, which he wore inside his stockings. *According to the advertisement,* a current of electricity ran up one leg and down the other, and of course the expected relief from his pains and aches came. Another old patient wears an electric ring, and occasionally takes it off and rubs

the rust from the inside of it—it is made of steel, and cost perhaps a quarter of a cent to manufacture, but he paid two dollars for it—and when the rusty discoloration shows on his handkerchief he tells me, "You see how it draws the impurities out of my blood." He has bought a number of these rings for his friends, for he knows that it has done him good, and he is quite sure that it will benefit others. For some of his lady friends he buys them gold plated; then they cost five dollars, but, as they are plated only on the outside, he assures me that they are just as effective. They are certainly not so unornamental as the plain steel rings.

It must be borne in mind that even the pain of such a real physical condition as cancer may be relieved by remedies which seem to have a good effect for a time, but which after a while are proven to have their effect on the mind and not on the body of the patient. Every new remedy for cancer, it is proclaimed, will, if it does not cure the disease, at least greatly relieve the pain caused by it. The X-rays seemed at first to be actually curative in many forms of cancer. Then it was said that in a great many cases they at least relieved the pain. Almost the same thing has been claimed for methylene blue and various other remedies for cancer. What this means is that cancer patients who are told that there is no hope for them, and who sit brooding over their condition, increase their sufferings to a very serious degree, and the administration of any remedy that promises to give them relief, that interests them for a time and gives them something to think of besides their hopeless condition with its constant discomfort, will make them much more comfortable than they would otherwise be.

Here is an instance of the effect of these remedies that I would like to impress upon your minds. It seems a mystery that so many healers, modes of treatments, and remedies should apparently cure people for a time and then prove to have no effect either for good or ill. They have no real physical effect, but they exert a strong influence upon the mind. Now the mind has much to do with pain and the endurance of it. Sometimes it is impossible to mitigate the pain, but quite possible to change the attitude of mind toward it, so as to make it more tolerable. People with minds intensely preoccupied often have no perception of pain. Men in battle have gone on fighting, unaware that they were mortally wounded, until loss of blood or

other prostrating influence caused them to sink in their tracks as they advanced. In the midst of excitement men are not infrequently wounded without knowing it. This is true also of women. In the midst of fires, especially in theatres, women have had a handful of hair pulled out, and on at least one reported occasion have had an ear pulled off, without knowing that anything had happened to them until their attention was called to it afterward. In the excitement of a railroad accident men often go around helping others though suffering from injuries which under other circumstances would make it impossible for them to move.

If, on the other hand, for any reason, a person's attention is called to a particular sensory impression, and the mind is concentrated on this, it will not be long before much discomfort will be associated with it. Any thought that will distract the mind will relieve the discomfort. For instance, if we have an itching sensation, and cannot get at the itching spot, the sensory irritation gradually increases. If we are in company that makes it impossible for us to relieve the irritation by scratching, we may become disturbed over the fact, fearful that if the itching increases we shall have to do something to relieve it, we may watch it sedulously lest it should increase, and the invariable rule is that it becomes much harder to bear. Anything that will distract our attention, however, will relieve us at once.

As a matter of fact, there may be at any time sensations over the surface of our bodies due to the fact that our clothing comes in contact with the skin which will make us very uncomfortable if we pay attention to them. We have grown used to bearing them, however; therefore they do not bother us. A savage who is asked for the first time to wear clothes wriggles and scratches and finds it hard to understand how we can think of anything else except our external sensations when we wear clothes. The first day of wintry weather, when we put on our woollens, we are likely to experience the same feeling. After a time, however, we cease to notice it. If you have ever been in a boiler factory or a cotton mill where looms were pounding on the floor I am sure you must have felt that it would be quite impossible for you to spend any length of time there without becoming distracted. You will find, however, that the workers are quite used to it, and that men and women have been known to spend many years there and remain in good health. As a matter of fact, they learn to

disregard the pounding in their ears just as the rest of us have learned to pay no attention to the many sensations caused by the contact of our clothes.

Whenever anything emphasizes our sensibility, as, for instance, when we sit before a fire or with our backs exposed to the sun, and the warmth increases the blood supply and makes the nerves more sensitive than before, the sensation of heat may become very uncomfortable. If we are sitting in the sun before a ball game begins, we wonder how we shall be able to bear it. When the game commences we wonder that the sunshine should have annoyed us so much before. If the game is exciting we shall probably forget all about it, although if rather slow we shall notice it between the innings.

On the other hand, when there is nothing to distract people's attention from their sensations, above all when there is a reason for dwelling upon them, and no compelling interest to divert their minds, sensations may become a very serious annoyance. People given to noticing their external sensations will usually find, for instance, that they have a queer feeling somewhere in the head. Either there is a sense of constriction in one of the temples, or a feeling of pressure at the back of the head, or a sense of tightness of the scalp over the vertex, or a pulling sensation above the temples on either side. Any normal individual who sits down, dismisses other thoughts from his mind, and dwells on his head sensations, will invariably find one of these present. At least I have never known anyone above the age of twenty-five who did not find some of them when he or she tried. Given an absence of gripping interest and some good reason for paying attention to this queer feeling, and the patient will have one of the many forms of nervous headache of which physicians hear so much. When questioned somewhat closely patients will confess that it is not really an ache, but a queer feeling.

In most of these cases it is not the annoyance or discomfort that patients complain of, but they fear that some serious condition is developing. Or they are quite sure that the feeling has some connection with conditions in their brain, and that it indicates some disturbance, organic or functional, in the central nervous system. This dread, like the dread of dirt that disturbs many people, or the dread of heights and of the dark that disturbs nearly all of us, may

become an obsession. In consequence they pay more and more attention to the queer feeling—even this word seems too strong for it, it is an unusual feeling. By the law of avalanche, this attention brings the sensation to more and more of the cells of the brain, multiplies its power to disturb, and adds to the annoyance it produces. After a time the patient can do scarcely anything without being conscious of it, it is really a source of great discomfort, and may even be called a torture.

No remedies we have will cure such a pain or ache or discomfort, whatever it may be called; only diversion of the mind can relieve it, and anything that diverts the mind of such people will cure them. If they take some remedy because of its novelty or some wonderful scientific quality supposed to be attached to it, or because it is connected with some new and marvellous discovery in science, or because of the emphatic promises of cure made by the inventor, they are almost invariably benefited because they cease to concentrate the mind on the feeling. Such people have to be cured, however; their pain cannot be explained away. It would seem to them quite absurd to accept the explanation that their pain is psychic and due to their own over-attention. For years they have been seeking, and usually receiving, an immense amount of sympathy because of the headache from which they constantly suffer. To admit, much less confess, that it was entirely due to their own super-consciousness, or was an exemplification of the law of avalanche, would never do. For them to be able to tell their friends, however, of a new and wonderful remedy, taking some credit to themselves for having discovered it because they have used it, or of some new system of treatment, or of a new healer by whom they have been "cured," not only justifies their years of complaining and shows that sympathy was not wasted on them, but puts them in the centre of the stage to attract attention, and, above all, to advise others how to be cured. Remember this in dealing with such patients. Understand their ills, but do not try to persuade them out of them, at least not directly.

You must produce a psychic impression. It is often a fallacy to assume that patients have not enough mind to cure themselves by mere mental influence. There must first be persuasion of mind, and then the exercise of their will. You know, after all, that there is much truth in the old saying that the people who find it hardest to

make up their minds are those who have the least mind to make up. There are any number of remedies, however, and directions for changing the mode of life, and habits of eating and sleeping and errors in diet to be corrected, which you can recommend,—suggestions that will help these people to get better. Above all, you will often find that they are taking more tea and coffee than is good for them, are not getting enough of fresh air, and that, almost as a rule, they are losing weight from solicitude about their diet and the gradual elimination from it of many nutritious articles because at some time or other some one has told them that their headache was due to an excess of acid in the blood, or the uric acid diathesis, or something like that. Correct what needs to be corrected, give medicines for various purposes as indicated, but do not forget that unless you change the patient's attitude of mind, break up the concentration of his attention on his feelings, and find some interest to absorb him, you will not cure him.

These are the patients who go around from one physician to another, helped a little at the beginning while the physician and his advice are a novelty, but, as a rule, eventually "cured" only by irregular practitioners of medicine who promise them much but give them nothing that has any physical effect, yet work what seems to the patient almost a miracle of healing. It is they who enable the quacks and the charlatans to live, and live well, in our time; it was they who were cured all down the centuries by the many methods of treatment that I have described. Such patients will continue until the end of time to be the subjects of unconscious mental therapeutics.

The principles underlying this case can be applied to many others. Some people suffer from pains in and around their joints and in their muscles. The pains are real enough, though they are rather discomforts than genuine aches. Often they are due to the fact that the patients are doing some routine work with muscles at a mechanical disadvantage, either because they do not know how to use their muscles properly, never having been trained, or because by reason of some anomaly of muscle origin and insertion they are incapable of doing certain routine work as easily as most other people. They get their pain or ache, as they call it, they dwell on it, and by concentration of attention they cause a widening of the capillary blood paths through the vasomotor nervous system, thus

producing a kind of hyperæmia which increases the sensitiveness of the nerves both at the peripheral and central end of the nervous system. The law of avalanche multiplies their already exaggerated sensation, and the consequence is an annoying discomfort that is almost constant. Anything that will divert their minds from the condition will greatly lessen the discomfort. It will not disappear, but when they are interested in other matters it will no longer be noticed. This is how these people are cured.

In the history of irregular medicine these are the individuals who have been cured more frequently than any others. They were cured by Greatreakes, by the application of magnets shaped in particular forms, by the Leyden jar in its primitive form, by Mesmer and then by Elisha Perkins, and in more recent times by various forms of electricity whenever a new mode of electrical development came, then by blue glass, and in our own time by all sorts of methods and systems of treatment with a special appeal—osteopathy, electric oil, oils by many other names, and all sorts of external and internal remedies, electric rings, electric insoles, electric belts, electric bandages, and all the rest.

A very interesting episode in the treatment of these so-called chronic rheumatisms or joint and muscle pains and aches happened in London at the beginning of the nineteeth century, when a wonderful new liniment was presented to the public as a cure-all for these conditions. The inventor of it was an adventurer named St. John Long, who had been convicted of felony at least once, and was thought to have been guilty of murder. He had made his living by his wits for years. Somehow or other he secured attention for this wonderful liniment of his, which in true proprietary-remedy fashion he declared that he had found only after long years of research and experimentation. All that was necessary was to rub any part in which there was pain with this liniment, and the pain would cease. He not only secured the notice of the public, but the nobility came to him, especially the elder members of the peerage, with their pains and aches, and were cured. They told their friends. Soon the St. John Long liniment was the fashion of the hour. Everybody was being cured by it. You had to get it from the inventor, who possessed the secret of its manufacture. Finally it cured so many cases that pressure was brought to bear upon the government, and a bill

was passed by Parliament awarding Long a large sum of money for the wonderful secret. The Government then published the formula for the benefit of sufferers throughout the world. It was found, however, to be only a conventional turpentine liniment made with egg as a menstruum instead of oil. Just as soon as this was ascertained the remedy failed to cure in the majority of cases. It was even claimed that St. John Long had not sold the real secret. There seems no doubt, however, that on this occasion he was honest. What the sufferers did not realize was that with the publication of his secret the mental effect of the remedy was lost. A secret remedy may confidently be expected to cure long-standing pains and aches, but a turpentine-white-of-egg liniment can scarcely be looked for to effect wonderful cures. People would feel absurd if their long-standing pains and aches could be cured so easily as this. It might even seem that they had little the matter with them, and had been wasting their friends' sympathy and their own time by nursing more or less imaginary ailments. Remember that many of these chronic cases of painful conditions are worse on rainy days, because all neurotic conditions are worse in damp weather, and because neurotic patients have less endurance on rainy days than at other times. They are only exemplifications of the law of avalanche multiplying the power of some originally not very serious sensation, to disturb a patient who pays much attention to himself, and in the treatment always bear this in mind.

THE PSYCHE IN DIAGNOSIS

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IT has been sagely remarked that the fads and medical errors of one generation are the authoritative teachings of the preceding one, but Owen Wister, in a scholarly address before the Philadelphia College of Physicians, has shown with what wonderful vitality many of the grossest superstitions have survived throughout countless generations of ignorance, and how wearifully slow is the fulfilment of the prophecy:

> Truth crushed to earth shall rise again,—
> The eternal years of God are hers;
> But Error, wounded, writhes with pain,
> And dies among her worshippers.

But perhaps, under the influence of cheap wood pulp, the improvement in typewriters, the Mergenthaler apparatus, and various ingenious reproductive arts, even the most ignorant of the present day may not have to wait so long. The ever-increasing flood of literature sweeping along rapidly and widely, leaving at every man's door each Sunday morning a heterogeneous mass of history, of laboratory results transmuted by feature writers into dogmatic teachings, of psychological vagaries, warped, twisted, and prejudiced; of religious doctrines, old and new, has changed all that. The progress of knowledge is correspondingly disorderly. It is no longer to be reckoned in generations, but in groups and sects, sucked into back currents, and retained in futile eddies from which each one must hook out and disentangle the set of opinions agreeing most nearly with his own standard of truth.

When the late Dr. Beard urged somewhat publicly the importance of faith as a means of promoting strictly pharmaceutic activity he was enunciating no startling novelty, but suggesting what had influenced the practice of physicians since the time when the memory of man runneth not to the contrary. He was quite vigorously criti-

cised, especially in England, where the usual family practitioner was an apothecary with an income dependent, not upon a fee for his diagnosis and advice, but upon the amount of drugs which he could induce his patients to pay for.

Opinions are changing within and without the medical profession. The scientific and popular are not without a reciprocal beneficial influence in promoting progress toward reasonable therapeutics and hygiene, social and public, but the tendency to a polarization in two opposite directions still exists.

The advertising columns of the press present a grim and convincing comment upon the growth of sects which reprobate recourse to drugs or to surgical procedure. The commercial instinct works actively and accurately, and the manufacturers know what they are about. The fortunes spent in advertisements go out for no trivial returns. We can hardly turn the printed pages of the papers or the magazines,—political, financial, religious, scientific, and pseudo-scientific,—or try to view the landscape from the car windows without being stared in the face by proof that blind belief in drugs is not yet extinct, but is rehabilitated and reinforced by fanciful pathologies with chemical or microbic connections, decked out in the most recent nomenclature, added to and mixed up with the labors of the coal-tar chemists.

On the other side the radicals have gone along in advance of science to condemn drugs in general, with little reference to special activities, as useless or worse. They claim that all disease is non-existent as a part of nature, or else it is dependent upon the psychic condition of the patient.

Among the profession almost a new specialty is evolved,—based neither upon laboratory psychology, nor old-fashioned psychiatry,—especially concerning itself with the diagnosis and treatment of supposedly non-organic or functional diseases or disorders.

It is not fortunate for the development of neurologic science, nor of rational therapeutics of any kind, that the terms "organic" and "inorganic" (or functional), "bodily and mental" (or psychic), or by the public "real and imaginary," have been considered so nearly interchangeable, and it is as little so from the therapeutic point of view that the line between the two contrasted states should have been accepted as a fixed one, so that they assume the relation of

"curable and incurable,"—necessarily amenable to different kinds of treatment.

Pathological anatomy, gross and microscopic, the knowledge of the internal glandular secretions, the chemistry of the excretions, and the great development of microbiology are every day crowding in upon the field not connected with known organic disease or poisoning.

The study of laboratory psychology puts the mental mechanism on the basis of percentages and of accurate measurements, but is useful in practical therapeutics chiefly as an adjunct to ordinary clinical study.

More and more as we seek to know the beginnings and the progress of nervous disease, we find them represented in demonstrable changes visible in the cerebral convolutions, the cellular structure, or as poison found in the test-tube, or separable by the filter, and flourishing in the thermostat. It is certainly within the limits of possibility that the visible changes produced by fatigue or by a condition of malnutrition which, in the lesser degrees, is capable of returning to complete normality, may be the beginnings of permanent degeneration when constructive metamorphosis is taking place with less activity.

Of course, the transfer of energy from the cerebral cortex to the muscular and secretory systems is through the nerves and, as concerns the latter, largely through the vasomotor nerves; but it is possible that there may be in some cases a more direct connection. Pflüger thought he had traced nerve-fibres directly into secreting cells, but his observations were not confirmed, though there is no apparent reason why it might not be so. The mutual relations between secretions and nerves are among the most quickly-acting and important; but, be this as it may, there is no doubt that degenerative processes and new growths, and to a considerable extent infections, are absolutely beyond the direct control of the psyche, no matter how ardently the wishes and beliefs of mankind may be directed toward their restraint. In the rare instances where the contrary seems to happen, doubt falls upon the diagnosis rather than upon errors in pathologic theory. Inexorable Nature brings us face to face with stern facts.

It is not, however, the rare and exceptional instances of supposed

miracles that we have to account for. Even in the very set of cases where it would reasonably be supposed that the control of the psyche over somatic metabolism would be most absolute we meet with the most wholesale and disastrous failures. Typical cases of insanity run their usual course, so much so that the foundress of one of the most widely spread cults of this class was obliged to invent a theory of "malignant animal magnetism" to cover the distress from which her followers and, at last, she herself were reported to suffer at the time of her death.

One of the most acute and trying cases of mental anguish I have ever seen was in a Christian Science reader who rejected my arguments of its inconsistency with her doctrines, with nothing but the incessant cry "Oh, you don't understand. You can't understand." It terminated in a very carefully planned suicide.

The fiancée of a young man with dementia præcox, both of them being "readers," could not see in the theory of "malignant animal magnetism" anything inharmonious with the fundamental doctrines. It was interesting to learn that the friends of the young man, although themselves "scientists," had removed the books with which he had been elevating his fellow-inmates of the Asylum to a higher plane of thought,—a procedure which seemed to indicate a worldly prudence more powerful than their faith.

The numberless apparently authentic testimonials are worthy of attention. We are apt to regard the flamboyant "ad" of anything with great suspicion, and it is very doubtful if any medical one, even when emanating from highly respectable sources, is ever unjustly so treated. They are surely not to be regarded as scientific statements, yet are not wholly lies. Their value as being connected with real names can easily be tested by any one who is willing to spend a few cents in postage.

A more interesting class is furnished by those who have allowed the desire to tell a good story,—the instinct of the *raconteur,* the love of the picturesque,—to get the better of their strict veracity. (In my first draft of the case to follow I found myself yielding to the same instinct.) A young woman, as the result of an accident, became a helpless cripple, and entered an institution—not the first in her series—where she came under the observation of the writer. She was unable to walk, and suffered much pain in the attempt.

The reflexes were normal and her limbs could be moved in bed, but she could not sustain her weight upon them. She stated, either then or later, that she had been given up by many physicians, that her case was hopeless, and she had been told that there was not a sound organ in her body. The upshot of nearly two years of treatment by massage, passive movements, and gradual exercise was that she *walked,* at first with assistance and then alone, not indeed as a professional pedestrian, but still *walked* with no aid except moral support, watching, and encouragement. Then there was a relapse from fright, and after some years recovery far more rapid than the original one under some kind of faith cure. She gave a glowing report of the case, and advised a psychologist now justly renowned to introduce "mental philosophy" into his school. The result was good and the advice excellent, but based upon many misstatements. She had either been most unfortunate in her selection of physicians or they had been sadly misrepresented, for I could not learn of any such statements as she had attributed to them. She *had walked,* and she *said she had not.* But there was no malice about it, nor, I think, any suspicion of malingering; yet when I confronted her directly with her absolute falsehood she said she did not think that kind of walking amounted to much. She spoke very well of the institution where she had stayed so long against the rules and the wishes of the trustees with the result of a real cure, emphasized or revived by the faith. To me the moral of the case is that it is not worth while to go too slowly with a case of hysterical exaggeration, and that an appeal to the marvellous is worth much more in such a case than an appeal to correct diagnosis or good judgment. I know of no way of graduating the respective influences of imagination and of direct observation except by the most careful process of exclusion.

One of the most original and epoch-making phases of the present psychopathic movement is that originated by Breuer and Freud, but elaborated chiefly by the latter with his disciples. It is concerned with the diagnosis (psycho-analysis) and treatment of some less common psychoses, particularly those classed as 'phobias, and takes as its basis the assumption—or fact—that in most cases of this class there can be elicited, perhaps in a condition of mild subhypnotism or, at least, in a candid and confidential frame of mind, facts among

the memories of babes and sucklings which have become by intricate processes of association and symbolism persistent forces in the present psychoses. It seems to be the repression or effacement of these early impressions which has led through paths not noticed by the patient himself but traced by the psycho-analyst to a new set of ideas which are the content of the 'phobia in the present consciousness. The treatment seems to consist in the thorough explanation of the tangle to the patient, and exonerating him from guilty responsibility. The skepticism and, indeed, repulsion which have been inspired by the enthusiasts of this (cathartic) method have been partly due to the exaggerated claims of its efficiency as a diagnostic method, but, especially at first, by the character of the facts disclosed and strongly emphasized.

Fixed ideas and obstinate 'phobias are said to depend almost universally upon recollections of a sexual nature by many years antedating the epoch at which they have heretofore been supposed to have a controlling or formative influence on the consciousness. It has been the forcible repression of these ideas which has been the foundation of the morbid condition, and the later discovery by psycho-analysis which has given the diagnosis and effected the cure.

An instance of the relief afforded by full confession,—a commonplace perfectly familiar to professional men of all occupations and sects,—may be found in one of the earliest of Freud's papers, not involving youth or any sexual element, in which a civil official, suffering long and grievously because of an insult from his superior which under rigid Prussian discipline he could give no sign of resenting, told the whole story to his physician and was cured. A more abrupt and American method was that of a struggling man who, when asked the banal question what he would do first if he had a million dollars given him, replied that, after putting it in the bank, he would reserve enough to go to New York and tell two or three men there what he thought of them, and then return peacefully to his family.

There are few persons but have felt the temptation "to give some one a piece of their minds," and it may be questioned whether the outspoken old-fashioned hysteric fit was not, in the long run, better for the subject than the silent suppression of the "*sweet sufferers*" who have no "organic," "bodily," or "real" disease, who

are picturesque for story writers but very wearing to their friends.

The intimate connection of sexual instincts, pure and otherwise, with the emotional life has been more carefully studied both in literature and science than is necessary here to dwell upon. If psycho-analysis after the elaborate method of Freud can alone show that infantile recollections are the chief, perhaps the only, factors in the formation of character, it should, of course, become a part of thorough examination in every case of mental disorder. According to this hypothesis, these recollections have, of course, practically disappeared from consciousness; but why should they for this reason be controlling factors rather than the incidents of boyhood which may be still vivid in the mind? It is true that infancy may mould to a great extent the character, and consequently the joys and sorrows, of the man; but, after all, heredity precedes infancy, and the educational period, good or bad, succeeds it. Why should impressions received so soon after birth be more ineffaceable than those of intra-uterine life, and those of later childhood's years be a so much less important factor?

The answer of the disciples would presumably be that observation has shown it to be so; that heredity in the individual can be studied only together with later influences, and that the cases in which it is apparently the dominant factor are almost entirely of the strongly degenerate type. They claim that the pernicious element in the development of a neurosis is the attempt at repression rather than the normal progress.

But it is not claimed that the method is one for every patient, and unless the psycho-analyst is himself an unusually well-balanced individual, able in diagnosis to distinguish between the old commonplace associations on the one hand, and, on the other, those memories which can be resuscitated by his mystic process and artificial symbolism; and as a therapeutist who well knows how to regulate and apply that dangerous nervine sedative, *sympathy;* who is able on occasion to be hard-hearted as well as kind-hearted, he may do as much harm as good.

These theories and discoveries, to which, of course, many objections may be urged as holding an important place in psychologic practice, may, however, be suggestive to the general practitioner, the family friend, or to the social worker, who comes first in con-

tact with the beginnings and vagaries of neuroses, great and small, which deeper inquiry into the earliest mental symptoms, not as yet disease but merely disorder, may explain and prevent as well as cure. He will perhaps discover that inquiries combined with less of the occult, mystic, special atmosphere and artificial symbolism, may conduct toward a reasonable standpoint, and he will not be so sure of sexual associations—at least, until he finds them.

He will not need to be told how often the neurasthenia, the obsessions, the early dementia, the hysteria, may prove to be the most potent factor of weakness in the heredity. He will probably place as much weight upon the influences of later childhood in domestic life and in schools, these still affecting the actual character as potently as those of the earliest childhood. And why not as permanently? That is one of the questions for his experience to answer. Why should not recent memories of harshness, cruelty, and neglect, or, on the other hand, of unrestrained indulgence, combined with an heredity of degeneration, be more disastrous to the mental state, and lay a heavier burden upon the community, than those which have been repressed since infancy? Would it not be as well to allow them to remain repressed, and be replaced by later and better ones? There are some weeds which can be covered up and killed by the covering; and there are others which must be dug up by the roots.

SYPHILIS OF THE PONS, MEDULLA, AND UPPER SPINAL CORD

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Philadelphia

THE advances made in our knowledge of syphilis in quite recent years are among the most important contributions to the natural history of disease. They are only comparable to the advances in our knowledge of malaria and the wonderful rôle of the trypanosomes. The first step in this progress, however, was not made by a physician, for it was Schaudinn, a zoölogist, who first saw an unstained specimen of the *Spirochæta pallida,* which is now generally conceded to be the living organism of syphilis.

Although syphilis is not essentially a nervous disorder, its ravages in the nervous system are of such supreme importance that this phase of its activity must take foremost rank in the study of its pathology. Indeed, it may be said, without exaggeration, that since the discovery of the spirochæte the study of nerve-syphilis has assumed an entirely new importance, and from this field have come some of the most interesting and fruitful developments. This is so because the central nervous system is the territory in which is displayed the worst havoc of syphilis and one in which are demonstrated some of the most remarkable discoveries in the life history of this organism. These have revolutionized many of our ideas about the pathology of syphilis of the nervous system.

It is not my part here to review all this history, but a brief reference to it is imperative. It has been discovered, for instance, that in many cases a very early invasion of the nervous system takes place after the initial lesion, and long before any symptoms of nervous disorder are manifested. This has been demonstrated by what are known as the four reactions in the cerebrospinal fluid, namely, the Wassermann reaction (also in the blood), the Noguchi and Nonne tests for globulin, and the presence of a lymphocytosis. It is too early to dogmatize at length on all these tests, for much remains yet to be

worked out, but we know enough to claim that in these matters we have a means in many cases of making an early diagnosis. The possession of these tests will put us on our guard and probably enable us to confirm an early suspicion of nerve-syphilis, based on beginning and fugitive clinical signs. This will be an immense advantage.

Our change of view with respect to the pathology of general paresis and locomotor ataxia is as interesting as it is likely to be complete. For many years it had been taught that these two diseases were *para*syphilitic (or *meta*syphilitic). Just exactly what was meant by the term "parasyphilitic" I have myself never been able to ascertain. It was a sort of metaphysical conception, as much out of place in medicine as the doctrine of original sin. The idea seemed to be that, although general paresis and tabes were due to syphilis, yet it was in a remote and roundabout way—a way, in fact, which nobody seemed to be able to describe plainly. This notion was countenanced by the fact that the pathology of tabes and general paresis presented a different picture from that of ordinary cerebrospinal syphilis. In the parasyphilitic diseases the essential process was in the neurons, or nerve-cells, themselves; in other words, it was a parenchymatous disease; whereas in ordinary cerebrospinal syphilis the disease was located in the blood-vessels and meninges, presenting the well-known endarteritis of Heubner, with gummatous exudation and lymphocyte infiltration. Two such distinct processes, it was thought, could not be due to the same cause acting in the same way. This has been the orthodox doctrine for many years.

It remained for Noguchi to show the falsity of this orthodox view, for in a recent paper he announced that he had found the spirochæte in 48 brains among 200 cases of general paresis and in one case among 12 of tabes dorsalis.[1] The protozoa were deeply embedded in the nervous tissue,—in fact, in the very neurons themselves, which would seem to show that they were quite competent to account directly for a parenchymatous, or neuronic, degeneration. Noguchi has followed this up with infecting rabbits directly with the tissue from general paretics and producing a typical syphilitic lesion in the testicle of the animal, from which he has recovered the spirochætes;[2]

[1] *Journ. of Experiment. Med.*, Feb. 1, 1913, p. 232; also a second paper in *Journ. of Cutaneous Medicine*, Aug., 1913, p. 543.

[2] *Journ. Am. Med. Assoc.*, July 12, 1913, p. 85.

and recently Forster and Thomasczewski, by employing the method of brain puncture, have been able to demonstrate living spirochætes in the aspirated cortical substance from patients with general paresis.[3]

Assuming that all these demonstrations are accurate—and there seems to be no reason to doubt them—the conclusion is irresistible that both general paresis and tabes are simon-pure syphilitic diseases, caused by the actual presence of the organism in the tissues, and that, therefore, the former conception of parasyphilitic diseases goes by the board. We may as well abolish the term "parasyphilitic" for good.

The fact that syphilis may cause other purely parenchymatous diseases than paresis and tabes has for some time been suspected; among these diseases are primary optic atrophy, primary lateral sclerosis, and even amyotrophic lateral sclerosis. Dr. Ludlum and I reported a series of cases, more than a year ago, of primary lateral sclerosis, from the Blockley clinic, in which the clinical evidence was very clear that we had to do with a syphilitic infection.[4] In such cases the lateral or motor tracts of the cord are involved in much the same way as the posterior columns are involved in locomotor ataxia.

Among the regions to which perhaps more attention should be paid in the discussion of cerebrospinal syphilis is the brain-stem, by which is meant especially the mid-brain, pons, and medulla, to which, for practical purposes, may be added the cervical cord. The invasion of this region by the spirochæte of syphilis results in some very characteristic clinical types. It is possible for us to see here both forms of invasion, *i.e.*, the parenchymatous and the vasculo-meningeal. The former is seen in certain nuclear degenerations, the latter in gummatous inflammation, endarteritis, and secondary softening. It is this aspect of brain-syphilis which I wish especially to discuss.

Nuclear degeneration in this region is seen in that curious affection known as progressive ophthalmoplegia, in which the nuclei of the motor nerves of the eyeballs are affected. The disease is selective and progressive, attacking the nuclei of the third and fourth nerves in the mid-brain and the nucleus of the sixth nerve, which is located in the pons at a considerable distance from the others. It results in complete paralysis of the muscles in the orbit, as well as of the iris

[3] See a paper by Wile, *Journ. Am. Med. Assoc.*, Sept. 13, 1913, p. 866.

[4] *Journ. Am. Med. Assoc.*, Sept. 28, 1912, p. 1173.

and ciliary body, so that the eyes remain motionless. Sir Jonathan Hutchinson, who was one of the first to describe this affection, taught that it was due to syphilis, and, although this has not always been proved, it is extremely probable. One proof of its syphilitic nature is found in the fact that nuclear degeneration of one or other muscles supplying the eyeballs and upper lids is seen in locomotor ataxia. Thus we may have a tabetic ptosis. In one case of almost complete ophthalmoplegia, which I reported some years ago, the patient had abolished knee-jerks, and there was the suspicion of a commencing optic atrophy. In time she probably developed tabes, but I lost sight of her.

Wernicke described a type which he called acute superior polioencephalitis, invading the floor of the aqueduct of Sylvius and neighboring parts of the mid-brain and even the pons. This is not a purely nuclear disease, but a more generalized destructive process, usually very acute, and presenting, besides ophthalmoplegia, other symptoms, such as optic neuritis, nystagmus, facial paresis, dysarthria, ataxia, and even hemiplegia. Some observers have claimed that alcohol is a factor in the causation of this disease, but as it is very acute, and marked by extensive destruction of tissue, it is not much like the usual lesions of alcoholism in the brain, and to my mind is more suggestive of a syphilitic endarteritis with secondary softening. Such cases, which are rare, can hereafter be subjected as they arise to the appropriate tests.

In considering the syphilitic pathology of this region it is necessary to bear in mind the blood-supply. This is furnished largely by the two vertebral arteries and the basilar, which they unite to form, and which pursues its course over the surface of the pons. These vessels give off nutrient branches which enter the nervous substance. The anterior part of this region is also supplied by the anterior inferior cerebellar artery. As it is the function of the spirochæte of syphilis to cause an endarteritis, especially in the inner coats of the vessel, and also a gummatous meningitis, we may have various secondary results, such as softening of the pons, or involvement of the cranial nerves emerging from it in the gummatous inflammation. I have seen, for instance, in two syphilitic patients a conjoint paralysis of the fifth and seventh nerves, due to this cause, and have also seen a diabetes insipidus, associated with a sixth nerve paralysis, in a syphi-

litic boy. The patient recovered under mercury and left the hospital, only to return within a year with a third nerve paralysis. In this case a syphilitic meningitis doubtless began on the surface of the pons, and later extended up into the interpeduncular space, where it caught the third nerve. Diabetes insipidus has been reported by a few other observers in syphilis of these cranial nerves, and Nonne, in his book on nerve-syphilis, has some references. Its exact mechanism is obscure.

Attention should be called here to that unusual clinical picture called a contralateral paralysis—a hemiplegia on one side of the body and a paralysis of one of the cranial nerves, usually the third or the seventh, on the other. Where the third nerve is involved the lesion is in the mid-brain; where the seventh nerve, it is in the pons. It is explained anatomically by the fact that the lesion involves the nucleus or root of the cranial nerve, causing its paralysis on that side, but involves the descending motor tract above its decussation, which takes place in the medulla below, causing a hemiplegia on the opposite side. These cases may be caused by a spot of syphilitic softening or by a gummatous tumor. In the case of an Italian the third nerve was paralyzed, causing a ptosis, external strabismus, and dilated pupil, with which was associated a hemiplegia of the opposite side. This is called the syndrome of Weber. At the autopsy a tumor of the mid-brain was found.

The space formed by the pons and the cerebellum, called the cerebellopontile angle, is a favorite location for neoplasms, syphilitic and otherwise. The seventh and eighth nerves especially are involved —the latter causing tinnitus, vertigo, deafness, and nystagmus—but deep structures may be invaded, according to the extent of the lesion, and thus there may be various forms of paralysis. In a patient at Blockley the seventh nerve was found, post mortem, stretched over a good-sized growth in this region, yet the patient had not shown any facial paralysis—a fact which illustrates the tolerance of nerves sometimes to a slowly-encroaching lesion.

There is also an acute or subacute bulbar palsy due to syphilis, in which there is paralysis of the lips, tongue, deglutition, and phonation. The primary lesion in these cases is usually vascular, and may consist of a thrombus in the vertebral or basilar arteries, or an embolus. Syphilis is only one of the causes which may produce this acute or

apoplectic bulbar palsy, and when it acts it is usually by an endarteritis. In these cases the wall of the artery, under the microscope, is seen to have undergone thickening, especially by proliferation of the interior coat, or intima; although in not a few cases which I have examined the infiltration by lymphocytes has not been confined to this coat. When the inner surface of the vessel becomes roughened a thrombus forms, followed by a secondary softening of the nerve-tissue. I believe Noguchi failed to find spirochætes in any vessel wall examined by him, but it is too early yet to say that they are not there.

These various affections have been sketched but briefly here and in outline, the salient features only being mentioned, for time and space forbid a full description. The object is to emphasize the importance of this general region as a territory of syphilitic invasion, with which possibly most practitioners are not very familiar. To keep abreast with the advances in syphilology, we must be prepared to recognize any and every slightest symptom, so as to act promptly. There is no time to be lost in brain-syphilis: the spirochæte waits for no man.

I report briefly a case which illustrates some of the points I have endeavored to bring out. I was indebted to Dr. George J. Schwartz for the opportunity of seeing this case in the Methodist Hospital.

James M., aged 51 years, single, white, born in Philadelphia, an iceman by occupation. Family history negative. He had used alcohol and tobacco moderately; had had a Neisserian infection when a young man, and a primary sore eight years before the onset of his present trouble. He had been treated at first for nine months, ostensibly with mercury, then stopped. He had had treatment again for several periods during the last four years. In June, 1912, the patient presented himself at Dr. Schwartz's office with tertiary lesions on his back and forehead, not involving the bone, and was put on inunctions of mercury and large doses of iodides. By September the lesions were healed, but treatment was continued. The patient apparently was perfectly well until early in December, when he noticed that he had difficulty in his speech and that his right foot dragged. Growing worse, he was admitted, four days later, to the hospital. It was at this time that I first saw him. He was complaining of intense headache; his mental faculties were clear, and he was not particularly paralyzed, for he walked across the room for me without my noting anything

Fig 1.

Syphilitic softening of the pons (somewhat diagrammatic). (Magnified.)

Fig. 2.

Syphilitic softening of the spinal cord (Magnified.)

wrong with his gait. He had at that examination no distinct aphasia. I concurred in the diagnosis of specific meningocerebritis.

I did not see him again until one week later, when I was once more requested to examine him. A great change had taken place, and his condition was extraordinary. He was literally paralyzed from his mouth down. He could not move a muscle in the arm or leg on either side, his respiration was embarrassed, he could not protrude his tongue nor move it in his mouth, his lips were entirely paralyzed, as were the lower fibres of the facial muscles on both sides, and he could neither speak nor swallow; in short, he had the appearance of the acute polio-encephalitis inferior of Wernicke, in which the lower part of the pons and the medulla are involved. By curious contrast the man's mind was perfectly clear, and he could roll his eyes in all directions on request, showing that the mid-brain structures were not involved. The patient died in less than two weeks after the onset of his nervous symptoms.

The autopsy revealed some very characteristic lesions. The lower anterior part of the pons on both sides was the seat of extensive softening, and the basilar artery was thickened. There was also some meningitis over this region. The medulla oblongata did not show gross changes to naked-eye inspection, but in the cervical enlargement of the spinal cord there was a large area of softening, causing a distinct cavity, in the posterior columns. Under the microscope these areas of softening showed simply broken-down nerve-tissue, but the membranes and the walls of the basilar artery showed lymphocyte infiltration; and the arterial wall was somewhat thickened. The lesions were also characteristically syphilitic in their irregular distribution, for the pons above and the cord below were damaged, whereas the medulla did not appear much involved. I attribute the purely bulbar symptoms, such as the paralysis of the tongue and of deglutition, to an interference with the blood-supply in the medulla, which, however, was not sufficient to cause softening in that particular region. The specimens were prepared by Dr. Ludlum. (Figs. 1 and 2.)

I should like to say a word about treatment. Since the introduction of salvarsan (which, by the way, this patient did not receive) there have been some observations which seem to show that this drug, when given intravenously, cannot be recovered in the cerebrospinal fluid withdrawn by lumbar puncture. Can it be that the spirochætes

in the cerebrospinal system are not reached by salvarsan? If so, would it be justifiable to inject that drug directly into the subdural sac? For some time Sir Victor Horsley has been urging that in cerebrospinal syphilis, when mercury is used, the drug, in the form of a 1 to 1000 solution of the bichloride, should be thus introduced beneath the brain-membranes. But salvarsan is capable of playing some ugly tricks, and for my part I confess I should not care to be the first man to inject it into the spinal subdural space.

N. B.—Since writing the concluding paragraph of the above paper, I have read the article by Swift and Ellis,[5] in which they describe their work in treating syphilitic affections of the central nervous system with intraspinous injections of the serum taken from syphilitic patients who had had intravenous injections of salvarsan or neosalvarsan. In some cases they used the serum from the patients themselves. The results obtained were noteworthy, and justify the hope that in this method may be found an efficient means of treatment. Marinesco, who injected neosalvarsan itself in doses of 5 mg. intraspinously in 13 patients, had some "unpleasant" results, and Swift and Ellis agree with him in advising against this method. They have injected high dilutions of salvarsan in monkey-serum intraspinously into monkeys, and found it too irritating to warrant its use in human beings.

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[5] *Archives of Internal Medicine*, Sept. 15, 1913, p. 331. See also the following papers by the same writers: "The Effect of Intraspinous Injections of Salvarsan and Neosalvarsan in Monkeys," *Journ. Experiment. Med.*, October, 1913, p. 428; and "A Study of the Spirochæticidal Action of the Serum of Patients Treated with Salvarsan," *Journ. Experiment. Med.*, October, 1913, p. 435.

Surgery

TRAUMATIC LIPÆMIA AND FATTY EMBOLISM

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I. INTRODUCTION

The entrance of free liquid fat into the blood stream as a result of trauma affecting the bone-marrow or the panniculi has become, through the freedom from infection gained by modern surgical technic, the most serious complication attending such injuries, and is a very common occurrence. It is highly probable that in every case of amputation or fracture of the long bones some fat is set free from the ruptured fat-cells and, either directly or by way of the lymphatics, enters the blood stream to cause a fat-embolism in the pulmonary capillaries, or, passing the lungs, in the capillaries of some other organ. When the amount of fat liberated is small, as it is in the majority of cases of bone injury, the results of such a fat-embolism may be unimportant and unnoticed; but it is evident that the gravity of the condition will depend upon the anatomical importance of the capillaries blocked by the fat-emboli. A very small amount of fat passing through the lung capillaries to lodge in certain capillaries of the brain may cause severe or even fatal disturbances; on the other hand, a relatively large amount of fat may be lodged in the pulmonary capillaries without causing great damage.

The amount of free fat liberated into the blood stream is often almost incredible, single sections of the various organs and tissues of the body showing, on microscopical examination, such numerous emboli that it would seem that the total amount of fat contained in the emboli must far exceed the fat-content of the injured bone. In some of these cases when the entire circulatory system is apparently flooded

with fat, the injury to the bone and bone-marrow may apparently be very slight, although in severe cases one or more comminuted fractures are usually present. Concussions, amputations (even when most carefully and perfectly performed), incomplete fractures, osteomyelitis, crushing or infection of the subcutaneous panniculi, laceration of fat-tissue by dislocations or efforts to replace dislocated bones, rédressement, brisement forcé, pressure upon atrophic bones, injuries to adipose tissue during labor or delivery, crushing of fat-cells of the panniculi during surgical operations, rupture of a fatty liver, purulent inflammation of fatty tissues, burns of the skin, etc., are the chief etiologic factors of traumatic lipæmia, in addition to the more direct lesions of the marrow following complete fractures. The lipæmia and fat-embolism resulting from any one of these causes may be slight or marked, without symptoms or with severe ones, terminating favorably or fatally. There is no clinical correspondence between the apparent injury and the degree of the resulting lipæmia. Injuries apparently identical may in one individual be followed by a fatal lipæmia, while in another not the slightest disturbance attributable to fatty embolism can be perceived.

The symptoms of traumatic lipæmia not only vary according to the degree and location of the emboli, but are of such a nature that the condition is rarely recognized before autopsy. The total number of cases reported is about three hundred and fifty, and the majority of these are not so clearly defined as to place them beyond doubt. In only about one-half of the number were thorough pathologic studies made. In autopsy and microscopic examinations important details are lacking, and strict analysis would exclude many of them. It is significant that eighty-six of the reported cases were observed in the seventeen years following 1862, when Zenker discovered fatty embolism,—a period when interest in the condition was still fresh. Except in Germany, few cases of fatal traumatic lipæmia have recently been observed, and the condition is regarded by the average surgeon as rare. In this country, particularly, there have been few records of its occurrence, and it is reasonable to infer that a correspondingly small number of diagnoses has been made. Most of the reports upon fatty embolism are found in German literature; and until recently these articles in the main pertained to its etiology and pathology; but within the last five years more attention has been paid to diagnosis and treatment. The text-books on general surgery give

a general impression that fatty embolism is a pathologic curiosity rather than a condition of practical interest, although its serious nature is usually admitted. The subject is either inadequately treated, or is discussed in general stereotyped statements. Scriba's monograph, published in 1880, forms the basis of these articles, even of the most recent; and his statement—an incorrect one, as shown by all recent work—that the temperature is lowered in fatty embolism—is perpetuated in the most recent English and American text-books on surgery. Meagre descriptions are given of its pathology, and the possibility of an antemortem differential diagnosis is usually not considered. It follows that in the failure to establish a diagnosis therapeusis must also be in vain. The therapeutics of fatty embolism recently formulated by Wilms and others have as yet been incorporated into few of the surgical text-books and systems. The time has come that more attention should be paid to this sadly-neglected branch of surgery, and that *the occurrence of fatty embolism after any injury to the bones be at least regarded as a possibility, and that preventive measures be instituted, or therapeutic efforts be made, whenever there is a suspicion of its occurrence.*

The medicolegal significance of fatty embolism is also great, but is wholly disregarded at the present time in this country. As it is a cause of death from apparently slight as well as more serious injuries to bones and soft parts, the necessity of recognizing its occurrence by means of properly-performed autopsies must be strongly emphasized. Fatal cases of fatty embolism from the common accidents of our large cities are every day diagnosed as "shock, coma, apoplexy, alcoholism, concussion, 'bad heart,' etc." In some of these cases the proper responsibility may be placed; but in others, of which I have personal knowledge, the responsibility for accidental and criminal violence was not placed because of the diagnosis incorrectly made by an ignorant coroner and coroner's physician. There should be further study and investigation of certain medicolegal aspects of fatty embolism; its postmortal appearance, its occurrence in burns of the skin, antemortem or postmortem, etc. The question of the thymicolymphatic constitution also crops up here, inasmuch as some writers affirm that there is an especial susceptibility to lipæmia and fatty embolism, to be explained by the assumption of the existence of such a diathesis.

In the writer's opinion, fatty embolism resulting from traumatic

lipæmia is an important surgical condition, which is not of rare occurrence but is probably, at the present time, in the absence of infection, the most frequent cause of death after fractures of the long bones. According to Gröndahl, fatty cerebral embolism is responsible for one per cent. of the deaths following bone injuries. It is apparently not an uncommon experience for surgeons to lose patients suffering from fractures or amputation within a few days after proper treatment had been given, and when all the conditions seemed favorable. Without warning, and without apparent cause, a state of restlessness, with mental anxiety, disturbance of heart and respiration, delirium, and coma, sets in, and death may take place within twelve to twenty-four hours. In explanation and justification of these fatal cases, the surgeon frequently takes refuge behind a diagnosis of shock or concussion. It is extremely probable that the majority of these cases are the results of traumatic lipæmia and fatty embolism, and it is highly desirable that more attention be paid to the differential diagnosis of fatty embolism, shock, concussion, diabetic coma, lymphatic struma, alcoholism, etc. In a relatively small postmortem service of 560 autopsies, the writer saw twelve fatal cases of traumatic lipæmia and fatty embolism, nine of these following fracture of the long bones, one occurring as the result of damage to adipose tissues received during labor and delivery, and another following a surgical operation for removal of a mammary cancer, and in one case of fatal burn of skin. Fatty embolism of the liver without pulmonary emboli was seen in a case of pituitary infantilism and adipositas following operation and prolonged chloroform narcosis. The most significant thing about these cases is the fact that very few accident cases come into this pathological service, and of the fracture cases terminating fatally and examined postmortem *all showed a marked fatty embolism as the cause of death.* In only one of these twelve cases had the condition been diagnosed clinically before death. Shock, heart-failure, acute cardiac dilatation, cerebral hemorrhage, pneumonia, sepsis, insanity, and alcoholism were the clinical diagnoses for the other cases, and the true cause of the symptoms remained unsuspected. Since these occurred in the practice or hospital service of clinicians of the highest standing, this general failure to recognize the condition can be taken only as an indication of its unsatisfactory status clinically. It has, therefore, seemed advisable to make a detailed study of these cases

with the purpose of emphasizing the surgical importance of traumatic lipæmia with resulting embolism, and, if possible, to extend the knowledge of its pathology and symptomatology.

Along both of the latter lines the research has been successful. A new clinical sign, *the presence of free fat and fat-granule alveolar cells in the sputum*, is the earliest positive evidence of the condition, being detected even before the appearance of free fat in the urine. The presence of fat-emboli in all of the organs and tissues of the body and the resulting pathological changes have been thoroughly studied, and new points in the general pathology determined,—thus new light is thrown upon the symptoms and the cause of death. Incidentally, new facts have been gained concerning fatty degeneration and the ability of different organs to take up fat.

II. HISTORICAL SURVEY

The history of lipæmia and its effect upon the circulation begins with the experimental work of Magendie during the years 1821–1836. While he had no knowledge of the occurrence of a pathological fatty embolism in man, *Magendie*[1] performed many experiments upon animals to determine the effects of the injection of oil into the circulating blood, and discovered that the fluid fat would not pass the smaller vessels, but blocked them mechanically. This obstruction of the capillaries he referred to an increased viscosity of the blood; and, without thinking of the possible occurrence of fatty embolism in man, he passed over this more immediate and logical deduction to the conclusion that in fevers, severe sweating, etc., the increased viscosity of the blood would lead to the formation of numerous capillary emboli, that would in turn cause pneumonia and inflammation of other organs. Magendie's descriptions of the experimental introduction of liquid oil into the venous circulation are classics for this particular field of experimental pathology and physiology. He described the symptoms resulting from small and large intravenous injections of olive oil, noted the dyspnœa, fever, râles, etc., portrayed the pathological changes in the lungs, and noted the presence of oil in the blood-vessels and alveoli of the lungs.

As early as 1669 *Lower*[2] had injected milk in large amounts intravenously into dogs, and this fact, with similar observations in the earlier literature, is sometimes referred to as the beginning of our knowledge concerning fat-embolism. *Virchow*[5] in 1862, *Schwick*[3] in 1864, and *Weber*[4] in 1865 showed that the experimental injection of emulsified fat in milk, pus, etc., was not followed by embolism. Other observers verified these conclusions, but the true explanation of the failure to produce fatty emboli through injections of minutely-emulsified fat has been frequently overlooked.

Virchow made repeated experiments with intravenous injections of oil, and noted the resulting dyspnœa after injecting a certain amount. When a larger injection was given, and the animal died, he found on autopsy an acute œdema

of the lungs, the air-spaces being entirely filled with foamy serum. He noted the injection of the pulmonary capillaries with fat. He also verified the experimental work of *Gluge* and *Thiernesse*,[6] who had claimed to be able to produce a fatty pneumonia and fatty liver and kidneys by intravenous injections of fat and by fat-feeding, but he was unable to confirm their results, and explained the fatty pneumonia as the result of oil entering the lungs through the trachea. After injections he found fat-emboli in the liver and kidneys, but no fatty infiltration of the parenchyma.

Frerichs[7] injected oil into the portal vein of dogs, and found that it did not pass the liver, but remained in that organ and was gradually taken up by the liver-cells, giving the appearance of a fatty infiltration.

H. Müller, in 1860,[8] was the first to observe fatty embolism in man while examining the eyes of a young man dying from chronic nephritis and who had suffered from amblyopia before death. In the choroidal capillaries of about 0.06 mm. diameter he found slender homogeneous plugs made up largely of free fat, partly in drops and partly in the form of granules. Müller thought that these emboli arose either from atheromatous foci in the ciliary arteries or from a cardiac thrombus. In the same year *B. Cohn*[9] observed fatty emboli in the capillaries of the brain and extremities in man, and regarded them as due either to fatty degeneration of the vessel wall or of the tissue surrounding it, or to the rupture of an atheromatous focus in some larger vessel. Neither Müller nor Cohn attached any pathological significance to these fatty emboli, but regarded them as accidental findings.

In 1862 *Zenker*[10] observed the first case of fatty embolism of the pulmonary capillaries in man. A railroad laborer was crushed between two buffers, and died shortly after. The autopsy revealed multiple fractures of the ribs, and laceration of the liver and stomach. The pulmonary capillaries were found to contain great numbers of emboli of fluid fat. Zenker thought the fat came from the stomach contents as the result of aspiration by the gaping hepatic veins. *Wagner*,[11] in the same year, reported two cases of pyæmia, one with caries of the pubic bone, both showing multiple fatty emboli in the pulmonary capillaries and in the vessels of the kidneys and heart. He believed that the fluid fat most likely entered the blood stream from an older abscess, and then, lodging in the capillaries of the lung and systemic circulation, produced metastatic abscesses. He reports four other cases of pulmonary fat-embolism, two of them being combined with pyæmia.

Grohe,[12] in a critical abstract of Wagner's work, suggested that the fatty emboli might arise from an agonal confluence of the fat normally present in the blood stream. *Lancereaux*[13] reported the presence of fat-emboli in the cerebral capillaries of a patient who had Bright's disease. He thought that the fat in the emboli might be attributed to fatty degeneration of the capillary walls.

During the years 1863–4–5 a number of dissertations and articles appeared, giving the results of the experimental study of various phases of the problem of fatty embolism. *Bergmann*,[14] working with cats, found that injections of fat into the venous circulation caused obstruction of the pulmonary capillaries and produced great circulatory disturbances. He observed also that a portion of the fat passed through the pulmonary circulation, causing emboli in the liver, kidneys, and other organs, but it was in part excreted through the urine. He noted also that the fat in the emboli was not permanently fixed there, but that a

part of it passed through the vessel wall into the neighboring tissues. He observed the rupture of the pulmonary capillaries, and the escape of blood and fat into the alveolar spaces. The presence of fat-droplets in the kidney tubules he attributed to the rupture of the distended glomerular capillaries. While he did not consider fatty embolism as an important primary pathological condition, he regarded it as a serious complication which might cause death through cardiac paralysis and pulmonary œdema.

Hohlbeck[15] carried out similar experiments on horses. In five animals experimented upon, intravenous injections of relatively large amounts of fat caused slight difficulty in breathing in three, coughing and dyspnœa in one, and marked emaciation in the other. All showed at autopsy hemorrhagic infarcts of the lung, lobular pneumonia, and numerous fatty emboli. The alveolar spaces also contained numerous epithelial cells showing marked fatty degeneration.

At this time appeared the work of *Weber* and *Schwick*, referred to above. These observers found that injections of pure oil into the veins caused fatty emboli, but that emulsions of fat produced no emboli. Areas of hyperæmia were found in the lungs, brain, spleen, liver, and kidneys, and these they regarded as the main pathologic conditions resulting from such embolism. They did not consider the condition in man a dangerous one.

Wagner[16] reported forty-eight cases of fatty embolism seen in man. Of these, fifteen were cases of complicated or infected fractures, twelve were acute suppuration of bones, fifteen were severe injuries to bones or soft parts quickly resulting in death, and six were chronic suppuration of different tissues. On finding numerous fat-droplets in a vein after an amputation for a complicated fracture, he believed that he had discovered the path of the fat from the periphery to the right heart. By experiments upon dogs he demonstrated that injuries to the bone-marrow soon produced fatty emboli in the lungs. Only after acute fractures were pure fat-emboli formed. Contaminated fat masses from old purulent foci gave rise to metastatic inflammations. Death might, however, ensue from hyperæmia and œdema of the lungs before the abscesses developed.

Uffelmann[17] reported two cases of pyæmia with numerous fatty emboli in the pulmonary capillaries, and upheld the view that emboli composed of non-irritating substances did not produce infarcts.

Weber[18] opposed the view that metastatic abscesses could be produced by fatty emboli. The entrance of a moderate amount of fat into the blood caused hyperæmia in the neighborhood of the embolus; larger amounts quickly resulted in death.

Roser[19] called attention to the fact that, in fresh complicated fractures, fat-droplets often flowed from the wound during the first few days. In a case of osteomyelitis he found, on cutting through the periosteum, a collection of bloody serous fluid rich in fat-droplets. He explained this as the result of a high pressure within the medullary canal which forced the fat of the marrow through the Haversian canals to collect beneath the periosteum. A similar collection of fluid fat was seen by *Gosselin*[20] about the knee-joint after crushing of the soft parts. Such collections of free fluid fat in the tissues may well serve as the source of fat which finds entrance to the vessels.

Busch[21] also took up the problems of fat-embolism from an experimental standpoint. As the result of numerous experiments he drew the following conclusions: Following destruction of the marrow there was always fat-embolism of

the smaller vessels and capillaries of the lung without appreciable lesions of the pulmonary tissues. The fat was taken up by the torn and gaping vessels of the injured bone, and in a lesser degree by the lymphatics. The absorption of the fat may be so rapid that fat-emboli may be demonstrated in the pulmonary capillaries within a few minutes after the injury. Inflammation and metastatic abscesses are not caused by the fat-emboli. Collateral hyperæmia and hemorrhage occur only when the fatty embolism is very marked; and only in such cases can the condition be fatal.

Fischer[22] first called attention to fatty embolism following fractures caused by bullets. *Waldeyer*[23] reported a case of osteomyelitis of the leg with extensive thrombosis of the veins. Numerous fat-droplets were present in the thrombus, and *Waldeyer*[23] inclined to the view that the pulmonary fat-emboli present arose from the degenerating thrombus rather than from the marrow.

Buttlewsi[24] is quoted by Park as one of the early observers of cases of fatty embolism. The original article is not accessible.

Joessel,[25] *Mulot,*[26] and *Feltz*[27] reported cases of fatty embolism without enriching our knowledge of the subject. Mulot observed a case in which fatty embolism followed the freezing of both feet.

Niederstadt[28] and *Klebs*[29] also called attention to the occurrence of fatty embolism in osteomyelitis. *Cohnheim*[30] held that a fatty embolus in a capillary could not in itself produce an extravasation, but that, when the emboli were numerous, infarcts could be produced as the result of purely mechanical factors.

Egli[31] found fatty emboli in two cases of cardiac thrombosis undergoing puriform softening and fatty degeneration.

Lücke[32] reported a case of subcutaneous fracture of the leg followed by death on the second day; numerous fatty emboli were observed in the lungs. Fat-droplets were found in an extravasation in the *tibialis antica,* also in the popliteal vein and in the right auricle.

Bergmann[33] was the first to make a diagnosis of fatty embolism during life; this was in a fatal case following fracture of the femur.

Wille[34] saw three cases of pulmonary emboli of fat without perceptible change in the parenchyma of the organ.

Czerny[35] studied fat-embolism, particularly from the clinical side, with reference to changes in temperature, pulse, respiration, etc. He concluded that the symptoms were variable, and that the diagnosis must eventually rest upon a known cause of fatty embolism. The latter can be regarded as a cause of death only when the emboli are found in important organs, such as the brain, heart, etc., or are sufficiently numerous to cause significant functional disturbances.

Küttner[36] held that fatty emboli could cause infarcts only when an extensive fatty embolism of the lung is present.

Schwenninger[37] reported two autopsies in cases of fatty embolism. In one death occurred three hours after the crushing of both legs; numerous fatty emboli were found in the lung capillaries. In the second case death took place after six hours, and the autopsy showed numerous fat-emboli, and an extreme œdema of the lungs.

Halm,[38] after examination of twenty-one cases of bone injury and experimental work upon animals, concluded that all injuries to bones caused fatty embolism. He observed no inflammation nor infarction of the lung. He

describes fully the symptoms of fatty embolism, and notes the occurrence of fat-droplets in the urine. In the pulmonary areas obstructed by emboli he found anæmia, and in the free portions hyperæmia. He could find no fat-emboli in animals whose mesenteric and subcutaneous fat had been injured.

Riedel[39] observed fat-embolism in nine cases of fatal bone injury, and in two of injury to the soft parts. He also carried out animal experiments, and concluded that all injury to bones caused fatty embolism, but obtained negative results from injuries to the panniculi. He was unable to prove that fatty embolism always followed osteomyelitis, but concluded that indifferent bodies introduced into the marrow produced much less fatty embolism than did agents which caused irritation and inflammation. He believed that the fat entered the circulation chiefly through the veins. He found no fatty embolism after injections of fat into the pleural cavity. In the lungs he found small hemorrhagic infarcts, œdema, fibrinous exudate, and fatty alveolar cells.

Heschl[40] reported one case due to a complicated fracture of the femur.

Hamilton[41] saw a case of multiple rupture of a fatty liver with marked fatty embolism of the lungs. Some emboli were also found in the kidneys.

Reyher[42] reported three cases of fatty embolism following bullet wounds; in one case the bone was grazed only, the marrow cavity not being touched.

Böttcher[43] also reported a case of fatal fat-embolism resulting from a bullet wound in the knee.

Flournoy,[44] in an examination of two hundred and fifty bodies in the Pathological Institute at Strassburg, found fatty emboli in twenty-five different conditions, only five being traumatic bone lesions. The other twenty cases included acute osteomyelitis, senile marasmus with red areas of degeneration in the bone-marrow, acute inflammation of adipose tissue, multiple contusions of subcutaneous adipose tissues, inflammation of soft parts and of bone, pyæmia, etc. Flournoy also carried out animal experimentation. He made subcutaneous injections of olive oil colored with *Rad. Alcannæ*, but without positive result. Incidentally he showed that fat-emboli could be found in the lungs of rabbits killed by a blow upon the neck. In discussing the pathologic features of fatty embolism, Flournoy decided that the fat entered the blood-vessels as free fluid fat through dilated normal or pathological openings in the wall, aided by some force from behind, probably extravasations of blood. After a certain time the fat-emboli are in part taken up by the surrounding tissues, in part excreted by the urine, while a remaining portion is converted into soap and dissolved. As a result of fat-embolism, Flournoy found hyperæmia, hemorrhages, small hemorrhagic infarcts, and œdema in the lungs. He observed no connection between fatty embolism and pyæmia. He emphasized the frequent occurrence of fatty embolism, believing it to be invariable after fractures, but somewhat less frequent after amputations and resections because of the lesser injury to the marrow and the absence of pressure from behind. Infective osteomyelitis, on the other hand, is probably always combined with it because of the prominence of these two causal factors.

Riedel[45] studied the urine of fracture cases, and found fat in forty-two per cent. He also called attention to the presence of peculiar brown casts in the urine of these cases, and explained them by the assumption that fibrin-ferment passed from the blood extravasation into the blood stream along with the fat.

Egli-Sinclair[46] made a partial review of the cases reported up to 1879, basing his article particularly on Flournoy's work, but published no new observations.

In the same year (1880) *Scriba*[47] critically reviewed all of the reported cases of fat-embolism, added original cases of his own, and conducted extensive animal experiments with the aim of solving the various clinical and pathologic problems appertaining to the condition. Scriba's work was the most complete treatise upon this subject to that date, and since its appearance but little had been added to the symptomatology or pathology of fatty embolism until within the last decade. We do not now accept all of his conclusions, but in the main they stand, and the majority of the statements concerning fatty embolism appearing in our text-books at the present time are based upon them.

Basing his conclusions upon the study of thirty-four cases, he states that, in the urine of patients suffering from fractures or injuries of the bone-marrow, fat appears very frequently, and usually with a certain regularity. In the cases in which it can be demonstrated with certainty it appears in different stages: the first on the second, third, and fourth days after the injury, the second from ten to fourteen days, and more rarely a third, or even a fourth, period after intervals of from six to ten days. At each appearance the urine contains fat for several days.

As the result of animal experimentation he found that fluid fat injected into the venous stream collected chiefly in the pulmonary capillaries and formed fat-emboli. A smaller part passes through into the arterial circulation, in which it in part forms emboli and is in part excreted by the kidneys. After several days (in man about eight to twelve days after the entrance of the fat into the blood) the emboli become free, particularly in the lung, pass into the greater circulation, and, after a time, make the complete circuit back into the veins, and again into the lungs. This circuit may be repeated many times. Small particles of fat may be taken up by the cells of the splenic pulp. Ultimately the greater part of the fat is excreted through the kidneys. In no other organ but the kidneys does the fat pass through an unaltered vessel wall. This statement in regard to the lungs is, however, given with some reservation. Scriba failed to observe the presence of fat in the sputum.

The action of the fat in the blood Scriba regarded as chiefly mechanical, but perhaps also chemical. He thought the fat could not be regarded as an indifferent body. The brown granular casts in the urine of fracture cases, which were described by Riedel, he did not regard as pathognomonic of fatty embolism, since they occur in other diseases characterized by disturbances of circulation in the kidneys and the presence of granular blood-pigment.

As to the action of the fat upon the heart, he denied the possibility of any serious effect upon this organ, and opposed the theory that sudden death in fatty embolism was the result of cardiac paralysis. Any disturbances in the action of the heart due to fatty embolism he thought could be explained sufficiently by the increased mass of fluid within the right heart. He found no evidences of inflammation associated with fatty emboli in the lungs or other organs, although hemorrhagic infarctions were numerous. He concluded that pure fat-emboli must be classed with the so-called bland or non-irritating emboli. Infarcts were found in these cases in which the animal lived at least twelve hours after the injection, but not when the periods were shorter. About old infarcts due to fatty emboli no

trace of inflammation was found. He concluded that fat-emboli constantly produce infarcts in the lungs when, through the blocking of a large number of capillaries in a given area, there results so severe a local ischæmia that the anæmic area dies.

In some of the animals experimented upon a general pulmonary œdema was found; occasionally it was only partial, or there was merely an increase of fluid in the pericardial or pleural sac. Scriba would refer the extensive pulmonary œdema seen in human cases of fatty embolism to an irritation of vasomotor centres resulting from the arterial anæmia following the embolism, also to deficient oxygenation of certain areas of the central nervous system. He considered the pulmonary œdema in fatty embolism to be an agonal phenomenon, and not the direct cause of death. The obstruction of the glomerular capillaries and the resulting retention of fluid he thought might also be a factor in the causation of pulmonary œdema.

In the kidneys he found stasis-hyperæmia and ecchymoses in addition to the fat-emboli. The liver contained numerous emboli and presented a marked passive hyperæmia. The cells of the peripheral portion of the lobules often showed abundant fat-droplets, and frequently the cells of the central zone of the lobule exhibited a similar fat-infiltration. In the spleen were found marked passive congestion, numerous capillary emboli, minute round hemorrhages, and occasionally large oil drops which were visible to the naked eye. Many of the pulp-cells contained fat-granules and droplets within their protoplasm.

Scriba regarded the findings in the brain and spinal cord as the most important of all. Passive congestion, arterial and capillary anæmia, perivascular hemorrhages, capillary apoplexies, and small foci of degeneration were found in both brain and cord. In a few experiments the ventricles contained serous, or a bloody serous, fluid associated with a slight degree of œdema of the brain substance. The fat-emboli were most frequent in the pia-vessels, the tela and choroid plexus. Scriba noted also fatty emboli with capillary apoplexies in the mucosa of the stomach, intestine, and bladder, choroid, retina, heart muscle, skeletal muscles, skin, etc., without other noticeable pathologic changes.

He confirmed the statements of others to the effect that fluid fat passes into the venous circulation after every injury to fatty marrow, either through fractures or primary injury to the marrow. The production of fatty embolism by injury to the subcutaneous or intermuscular fat he could not confirm by his experiments. Out of 177 cases of fatty embolism collected by Scriba, in only fourteen instances could the fatty embolism be regarded as the cause of death, and some of these he regarded as doubtful. He therefore concluded that pure fatty embolism can only rarely be fatal. Since the amount of fat entering the veins in human cases is relatively much less than that injected experimentally into animals, Scriba does not believe that pulmonary fat-embolism in man can ever be so extensive as alone to cause death. On the other hand, he thinks that emboli in the central venous system may very frequently result in death. In support of his view that cerebral embolism is the cause of death, Scriba holds that the symptoms of collapse, weakness, apathy, disturbance of consciousness, subnormal temperature, coma, vomiting, paralysis, lessened sensibility, loss of reflex excitability, sense of pain, etc., all point to cerebral embolism. A further symptom-complex is found in the dyspnœa, etc., due to pulmonary embolism. Scriba regards the occurrence of fever as evidence that fatty embolism is not the cause of death. In this he

is opposed by all recent investigators. As the most important clinical sign he emphasizes the occurrence of fat in the urine. Next to this he places transitory attacks of dyspnœa, fall of temperature, occasional slight hæmoptysis without fever or marked physical signs, irregularity of the heart, collapse, paleness of the skin, Cheyne-Stokes respiration, convulsions, cramps, and loss of reflex excitability.

Déjerine[48] reported two cases after fractures. In one case crushing of the lower portion of the leg was followed by death within two and a half hours. The pulmonary capillaries were found filled with fat. In the other case fracture of the right parietal bone was followed by death within thirty-six hours. The pulmonary vessels were filled with fat; other organs were not examined. Later Déjerine carried on experimental work, obtaining results differing from those reported by Flournoy and Halm. He did not succeed in producing fatty embolism by fracture of the skull or the extremities, and could cause it only when a marrow cavity was irritated by some foreign body. In his experiments he used laminaria tents.

Von Recklinghausen[49] noted the occurrence of fatty degeneration of the myocardium in fatty embolism, and called attention to its importance.

Wiener[50] believed that in the great majority of cases fat-embolism was a perfectly harmless process. The rapidity of the excretion of the fat he attributed wholly to the power and energy of the heart action. He observed no disturbances of nutrition in the tissues of the brain, kidneys, spleen, muscles, etc., and concluded that only in extremely rare cases could fatty embolism reach such a high degree as to be fatal.

Sanders and Hamilton[51] reported a case of lipæmia and fatty embolism in a man, aged twenty-four years, dying of coma and extreme dyspnœa. Fat-emboli were found in the capillaries of the lungs and kidneys. None were seen in the brain. They regarded the fat-embolism as the cause of death.

Southam[52] reported the case of a man, aged forty, with a compound comminuted fracture of both legs at the lower third. Amputation was performed. On the following day the temperature rose to 103°, the patient became restless and excited, cyanotic, with marked dyspnœa, and died thirty-five hours after the operation. Sections of the lungs showed a marked fatty embolism.

Jolly[53] observed three cases after simple mechanical injury of the subcutaneous panniculus, as the result of self-inflicted bruises produced in patients violently insane. He reports also the two cases earlier reported by Fitz and Flournoy.

Moullin,[54] in twelve out of fourteen cases examined, found fat-embolism of the lungs and kidneys. Seven of these were fracture cases; the other five were respectively pyæmia following acute periostitis, necrosis of fibroid tumor of uterus after abortion, ovariotomy, removal of sequestra, and dislocation of the hip with much laceration of fat-tissue. In one case fatty emboli were found in the lung, although the man had been instantly killed by fracture of the spinal column. No examination of the brain was made in any of these cases. He refers to a case observed by *Fagge* in which fatty embolism followed a primary amputation.

Saundby and Barling[55] found pulmonary fat-emboli in nine cases of severe wounds and injuries fatal within two days. They also saw fat-droplets in the clots of a diabetic with milky blood. They refer to a case of farcy observed by Bendall, in which fat-emboli were also seen.

Minnich[56] called attention to the rarity of fatty embolism in children, and explained this by the small fat-content of their bones. He found fat-embolism in

all cases of fracture of the long bones, even when the bones were small, and poor in fat-content.

Skirving[57] reported a case in a healthy man of forty who suffered a compound fracture of both bones of the leg. Next day, while conversing, he became unconscious. Respiration was regular; a few râles were heard at the base of the lungs. Urine contained granular casts and oil-drops. Temperature rose to 104°, respirations 60; patient became cyanotic, died on third day, temperature rising to 105.8° after death. Autopsy showed fatty embolism of lungs and kidneys, and punctiform ecchymoses under endocardium. The brain was not examined.

Pinner[58] observed a case of fracture of the fibula, with small skin wounds and extensive laceration of the skin of leg and thigh. Patient died on the third day. Autopsy showed many fatty emboli in the lungs, fewer in the kidneys, and marked œdema of the lungs.

Zwicke[59] reported two cases. One, a man of twenty-seven, had a subcutaneous fracture of the neck of the femur. On the next day restlessness and tremors of the hands and tongue developed, the symptoms resembling the onset of delirium tremens. Died on fourth day at beginning of chloroform anæsthesia. Lungs showed marked fatty embolism; brain not examined; œdema of lungs; marrow crushed.

The second case was a male, seventy-two years old, with fracture of the upper end of the humerus. On the following night he developed restlessness and delirium resembling delirium tremens, and died in collapse on the third day. Marked fatty embolism of lungs. Brain not examined.

Socin.[60]—Male, aged eighteen, with fracture of right femur, and complicated fracture of right tibia. Died on third day. Fat-embolism of lungs, brain, kidneys, and heart.

Prichard.[61]—Quoted by Graham as reporting an apparently authentic case.

Coats[62] also quoted by Graham as reporting an authentic case.

Wahncau.[63]—Girl, aged eight, fractures of both tibias, and infarction of fibula. Died on the third day. Fatty embolism of lungs, heart, and kidneys, and pulmonary œdema found at autopsy.

Bruns.[64]—Two cases from Bruns's clinic reported by Meeh, one a male, aged twenty-three, with multiple fractures of right humerus, fracture of radius, femur, and other bones. Died four hours after injury. Marked fatty embolism of lungs. The second case was a male, aged forty-two, with fractures of many bones. Died six hours after injury. Autopsy showed marked fatty embolism of lungs.

Warnstedt[65] describes briefly a fatal case of fatty embolism following extensive contusion of the subcutaneous panniculus, caused by an apparently slight injury.

Meeh[66] collected the cases of fracture in which the cause of death was ascribed to fatty embolism, 113 in all, including the 86 cases collected by Scriba. Of these he regards only fifteen as undoubtedly due to fatty embolism. These are the cases observed by Halm (four), one by Busch, one by Riedel, one by Schwenninger, one by Böttcher, one by Pinner, two by Zwicke, one by Socin, one by Wahncau, and the two from Bruns's clinic reported by himself. In only eleven of these cases was death ascribed to pulmonary fatty embolism alone. Only in four was cerebral fatty embolism observed, and in these cases there was a flooding of the entire circulatory system with fat. In eleven cases there was general or partial œdema of the lungs. In the two cases from Bruns's clinic, both of whom were fat people, there

were numerous fractures with marked crushing of the soft parts; the lungs were full of fat, but none was found in the systemic circulation. Accordingly he does not accept Scriba's dictum that fatty embolism is fatal only when emboli are found in the brain. He concludes that fatty embolism is a very common complication of fractures, but in the great majority of cases is not dangerous. Only rarely does it terminate fatally, either as the result of extensive embolism of the lungs or brain, or of the combined action of the emboli on various organs and the consequent disturbance of their functions.

Barack[67] discussed the cause of death in fatty embolism, and observed that the most important point in the diagnosis of pulmonary or cerebral embolism is the length of time between the entrance of fat into the circulation and the death of the patient.

Colley[68] reported a case of fatal fat-embolism after brisement forcé without injury to the bones. He gives a detailed description of the gross and microscopic findings, and called especial attention to the changes in the heart muscle,—areas of fatty degeneration surrounding capillaries filled with fat-emboli. He includes a second case of brisement forcé in a girl, eighteen years old, showing late rhachitic changes and marked atrophy of the bones. Twenty days after the operation the patient developed paralysis of the right facial nerve and arm, the temperature rose to 40° C., deep coma set in, and three days later death ensued with symptoms of pulmonary œdema. Autopsy showed a small number of fatty emboli in the lungs. The most important feature of Colley's report is the focal fatty degeneration of the heart muscle. He reviews the literature imperfectly for similar observations, and criticises Scriba's dictum that in fatty embolism death is never due to cardiac disturbance. He quotes Busch's observation of fatty degeneration of the heart muscle in the first case of fatty embolism he described, the patient dying thirty-six hours after the injury. Busch attached no significance to this change, and from his protocol we can not be sure that there was no other cause for the degeneration. In his survey of the literature he found no especial stress laid on the cardiac changes in fatty embolism. No previous writer had demonstrated so clearly that fatty degeneration of the heart is the result of obstruction of the capillaries by fat-emboli.

Hirsch[69] reported a case of comminuted fracture of the tibia and fibula. On the third day the patient developed restlessness, dyspnœa, and subnormal temperature, and died apparently from collapse. Lungs showed fatty emboli.

Ribbert[70] reported human cases and results of animal experiments. Showed that simple concussion led to fatty embolism in animals.

Ferguson[71] observed a case of fatty embolism of the lungs in a woman twenty-two years of age, whose breast was freely incised for diffuse suppuration. A milky, oily fluid escaped. Following the operation there was marked dyspnœa and restlessness. The lungs only were examined, and these showed marked fatty embolism.

Finotti[72] reported a case in a young man, aged eighteen years, who, after jumping from a second-story window without apparent injury, died twenty-four hours later from marked fatty embolism. Bloody effusions mixed with fat were found in the left knee and in both ankle-joints. The talus in both ankle-joints was fractured, as was also the head of the left tibia.

Ahrens[73] collected the cases of fatal fatty embolism following brisement forcé, abstracting the cases reported by Wahncau, Colley, and Finotti. He mentions

also a case of fatty embolism following resection of the knee, which was reported by *Vogt*,[74] and concludes that even the most cautious use of force may cause such damage to the bones that a fatal fat-embolism may result.

Pomatti[75] reports a single case of cerebral fatty embolism with countless miliary ecchymoses of the brain substance, following subcutaneous fracture of the tibia. He notes the occurrence of multiple fibrin-thrombi in the cerebral vessels, and necrotic changes in the tissue about the plugged-up cerebral vessels. Symptoms set in twelve hours after accident; death occurred on the third day. The symptoms were mental stupor, trismus, tonic convulsions of extremities, ascending temperature, and collapse.

De Groube[76] collected 211 cases from literature and reported one fatal case following fracture.

Lympius[77] reported the case of a female, aged seventy-one years, dying suddenly during chloroform narcosis while her knee was being straightened. Lungs showed fatty embolism. There was no fracture. Subcutaneous panniculus was thick, and the muscles showed marked fatty change.

Payr[78] reported the fifth case of fatty embolism following forcible stretching of the limb for contracture. Ether narcosis. On the next day the patient collapsed, became cyanotic, dyspnœic, and restless, although the mind was unclouded and the temperature normal. Autopsy showed fatty embolism with lymphatic status. Payr attempts to demonstrate that the relationship between the latter condition and death from fatty embolism explains the disproportion between the trauma and the fatal outcome.

In a second publication Payr (1899) distinguishes two kinds of fatty embolism, a respiratory and a cerebral form, and reports two more fatal cases of pulmonary fatty embolism associated with the status lymphaticus.

Jentzsch[79] added ten cases from literature to the fifteen positive cases of fatal fatty embolism following fractures collected by Meeh. He gives details of three more cases (one following brisement forcé) from among the two thousand fracture cases in Bramann's clinic; fever occurred in all three cases, and this he regarded as a ferment-fever due to the "resorption of fibrin-ferment."

Carrara[80] found fatty emboli in the lungs in twenty-eight cases out of 102 examined. In seventeen cases of fracture they were found in seventy-six per cent. It was found also in diseases of the lung and kidneys, in burns and scalds, and in phosphorus poisoning.

Eberth[81] compared two cases of fatal fatty embolism, one occurring in a healthy man, the other in an anæmic girl suffering from chronic rheumatism. In the first case numerous fatty emboli were found in the general circulation, in the second case only few, although the lungs were full of them. Eberth explains this as the result of the earlier disturbance of the circulation in the lung of the girl, the fat not permeating the altered lung as readily as the normal one.

Hämig[82] made a special study of fatty embolism of the brain from the clinical side rather than from the pathologic. Out of 377 male patients with fractures in the clinic at Zürich in the year 1898–99 there were five deaths for which the only cause that could be found was fatty embolism. All five showed also fat-embolism of the lungs, but the symptoms were those of cerebral disturbance. One of these (reported by *Krönlein* and *Weismann*[83]) was trephined as the result of a mistaken diagnosis of meningeal hemorrhage (compare below). Symptoms, such as increasing stupor, delirium or coma, rising temperature, etc.,

appeared within six to eight hours after the accident. Death took place within a day and a half to six days from the time of injury. In two cases fat-emboli were found in the lungs, heart, and brain; in two in the lungs, heart, brain, and kidneys; and in one in the lungs, heart, brain, kidneys, and spleen. There was œdema of the lung in four cases. Fat-emboli and hemorrhages with surrounding yellowish zone were found in the heart muscle, and Hämig thinks it possible that these had an influence in bringing about the fatal result. He selects from literature twelve cases which show the especial features of fat-embolism of the brain: one case each of Busch, Czerny, and Flournoy, three cases of Halm, one of Socin, three of Ribbert, one each of Pomatti and Colley. He refers also to a case regarded by *Demisch*[81] as a case of healed fatty embolism of the brain. A young man, twenty-three years of age, after a fracture of the thigh developed on the fifth day fever, stupor, and dyspnœa; on the next day apathy and paresis of extensors of fingers. Slow recovery.

In the brains of his own cases he found miliary hemorrhages and thromboses, and attributes the symptoms of cerebral disturbance to the production of these rather than to the mere presence of fatty emboli in the cerebral vessels. Since fat is found in the urine of many cases of fracture with few or no symptoms, and from the fact that if fat gets to the kidneys it must also reach the brain, it is evident that in these light cases there was no serious damage to the brain tissues.

The increase of temperature observed in his cases Hämig explains by the assumption of an irritation of the heat-centre, and suggests that Scriba's failure to observe fever in the animals experimented upon was due to the fact that, after the first twenty-four hours, no temperatures were taken. Hämig also advances the theory that the "delirium nervosum" seen rarely in cases of fracture is probably a secondary result of fat-embolism of the brain.

Engel[83] observed a case of fatty embolism in a tuberculous lung following rupture of the liver caused by a slight fall. Symptoms of cyanosis, dyspnœa, foamy expectoration, pulmonary œdema.

Brodbeck[84] reported three new cases of fatal fat-embolism following rédressement, fracture of the bone, and injury to soft tissues respectively. To these he adds a fourth case of pulmonary fatty embolism in a man who had been run over by a heavy wagon. As this case showed other fatal injuries he did not regard the fatty embolism as the cause of death.

Fuchsig.[85]—Case of a seventeen-year-old girl falling from third story. Fracture of leg. On the following day unconsciousness, tonic and clonic convulsions, rising temperature, fat-drops in the urine. Death 72 hours after trauma. Fat-emboli in lungs and brain. Large hemorrhage in corpus striatum. Open foramen ovale.

Preindlsberger[86] is quoted by Brenziger as reporting a case of fatty embolism following rédressement.

Westenhoeffer[87] describes two cases of "cadaveröser Fettembolie" due to postmortem changes caused by the *Bacillus aërogenes capsulatus*. Hüttemann confirmed this by two similar observations, but the views of these two writers that fatty embolism may be a postmortal process are not tenable.

Euphrat[88] reported a death from fatty embolism during narcosis for treatment of a fracture of the neck of the humerus. Autopsy showed extensive fatty embolism of lungs.

Joachim[89] and *Seegers*[90] each reported a single case of fatal fatty embolism

with cerebral hemorrhages following fractures, without adding anything to our knowledge of the subject. Seegers produced fatty embolism of the cerebral vessels experimentally in animals without causing hemorrhages of the brain, and assumed, therefore, that some other factor is necessary than the mere plugging of the vessels.

Brenziger [91] reported two cases of traumatic lipæmia. One, a laborer, thirty-nine years old, fracture of both legs. Pulse small, sensorium clouded, restless, fever. Died on following day. Fatty emboli in lung. Second, a laborer, twenty-seven years old, fracture of tibia. Same symptoms. Died on third day. Emboli of fat in lungs, small fat-emboli in vessels at base of brain.

Rössle.[92]—Portovenous fat-embolism of liver in case of infarction of mesentery and small intestine. Fat-emboli and localized areas of fat-infiltration throughout liver. Necrosis of overloaded liver-cells. Free fat in bile-passages. Absorption of fat into liver-cells by way of "Sternzellen."

Davidson [103] reported a case of complicated fracture of both legs in a young man of twenty-five years, with death from fatty embolism. Autopsy showed extensive fatty embolism of lungs, brain, and kidneys. Because of the relative infrequency of emboli in the vessels of the liver and the peculiar fatty infiltration of the liver-cells, Davidson concludes that the liver-cells removed a large part of the fat from the circulation.

Aberle [105] reported a number of cases of fatty embolism following orthopædic operations. The diagnosis was not always confirmed by autopsy. In one fatal case, in a child six years old with congenital club-feet, the operation of resection and rédressement was performed with normal narcosis, but cyanosis suddenly developed, and the child died six hours after the operation without recovering consciousness, in spite of the most extreme measures. Autopsy showed extensive pulmonary fat-embolism.

Riener [106] advises the insertion of a cannula into the saphenous vein, pushing it into the femoral as far as possible. When the constricting band around the limb is removed, the rush of blood through the cannula will wash out any fat that may be there.

Eichhorn [107] reported a fatal case of extensive fatty embolism of lungs, heart, and kidneys in a man seventy-one years of age, after a severe concussion of the skeleton without fractures.

Frischmuth [109] reported three cases of fatal fat-embolism from the surgical clinic at Königsberg, two of which were confirmed by autopsy. He repeated Ribbert's experiments on rabbits, and confirmed his findings that simple concussion is sufficient to produce fat-emboli in the lungs, and that crushing of the spongiosa without concussion causes fat resorption. In common with Lexer, he advises the use of a saw instead of a chisel in operations upon the spongiosa.

Wilms [111] reported a case of falling from the second story. Sixteen to twenty hours later the patient became soporific, the temperature rose to 39° C., respirations to 40. No fractures. Believing the cause to be fatty embolism with absorption of fat through the lymphatics, Wilms opened and drained the thoracic duct, large drops of fat appearing in the lymph. The patient recovered gradually, the fistula closing on the ninth day.

Von Lesser [112] carried out experiments with reference to the therapeutics of fatty embolism. Salt solution was injected directly into the right ventricle to revive the heart's action after air or fat had been injected into the jugular.

Bergemann[113] ascribes fat-embolism to the forcing of fat into the veins by the crushing of bones. He discountenances bone crushing in surgical operations, and also explains the occurrence of fat-embolism after rédressement without fracture as the result of direct pressure upon the atrophic ends of bones, which in turn forces fat into the veins. He believes that the lymphatics may take up some fat, but not enough to cause severe fatty embolism.

Fuchs[114] reported two cases of fatal fatty embolism; in one there was concussion without fractures; in the second fracture of the skull and rupture of the spleen. He mentions also a fatal case of fatty embolism in a young girl subjected to brisement forcé under chloroform anæsthesia. The clinical diagnosis in this case was chloroform poisoning; the autopsy showed marked fatty embolism. He believes that cases of fatal fatty embolism as the result of severe injuries without fracture of bones are not rare. He reports also the finding of fat in the lungs of eclamptics, in cases of delirium tremens, after resection of the intestine, after amputation of the mamma, etc., but in all of these the amount of fat was small.

Bürger[115] discusses the medicolegal significance of fatty embolism as a cause of illness and death, and emphasizes the fact that fatty embolism is a vital phenomenon.

Fuchsig[116] reviews the literature. He experimented with frogs, rabbits, and cats, using injections of pure olive oil and emulsions of the same. He concluded that the effects of intravenous and intra-arterial injections of oil depend upon the amount of the oil used and the rapidity of the injection. Death occurs only after injections of 2 Cc. to every 1000 Gm. of body-weight. The death may be pulmonary, cardiac, or cerebral; the pulmonary form is most common. When the intravascular pressure is sufficient to overcome friction, the oil passes the capillaries.

Schanz[117] reported ten cases of orthopædic operations on bones followed by signs of fatty embolism, the cerebral vessels evidently being clogged by fat from bone-marrow. One case was fatal; in another there was hemiplegia lasting some weeks. All of the others recovered after routine saline infusions, the salt solution being injected at several points to accomplish most quickly the desired dilatation and flushing of the capillaries.

Benestad[118] reported three cases of recovery from fatty embolism with multiple punctate hemorrhages in the skin. All were young workmen with fractures of the bones of the legs. After the injury they showed great restlessness, with gradually developing apathy, stupor, and dyspnœa; there was no cyanosis, but a weak pulse, pain in the lungs and severe cough, sputum like that of pneumonia. All recovered by the end of the second week.

Pacinotti[119] reported fatty embolism following severe burns of the skin, and holds that the hemorrhages so frequently seen after burns of the skin are due to fatty embolism and the resulting injury to the blood.

Fritzche[120] made an experimental study of fat-embolism in rabbits and dogs. He concludes that cutting of the bones may lead to fatty embolism, the veins taking up particles of fat. The mere concussion of the bones is sufficient to cause fatty embolism by the lymphatic route, the lymphatics taking up the fat and passing it into the circulation. In the latter case drainage of the thoracic duct may ward off danger, if this operation is performed when the symptoms of traumatic lipæmia first appear.

Godlee and Williams[121] observed two cases of fracture of the thigh, one a simple fracture, the other with some crushing of the bones. Within twelve hours both were comatose without noticeable pulmonary symptoms, the temperature rose rapidly, the pulse was low and rapid. Both died. No signs but those of fatty embolism, and no localizing lesions in brain. Superficial resemblance to compression of the brain, but without the pulse of compression.

Gröndahl[122] makes the most complete study of fatty embolism since Scriba's paper, critically reviewing the literature, and adding nine new cases (five of these cerebral fatty embolism with fatal termination and but three autopsies, three cases with cerebral symptoms but recovering, and one fatal case with pulmonary symptoms). In addition he reports on the investigation of the occurrence of fat-embolism in 108 cases of death from other causes, and describes a series of animal experiments. He compares the findings recorded in literature with his own, and gives a complete *résumé* of the etiology, symptomatology, and pathology of fatty embolism, without the addition of anything new. He emphasizes the importance of the process, the need for differential diagnosis and treatment. He notes the occurrence of fever in contradiction to the commonly accepted statement of Scriba that there is no fever. He does not mention the presence of fat in the sputum as a diagnostic sign.

Ziemke[123] discusses the postmortal origin of fatty emboli.

Beitzke[124] reports a case of fatal fatty embolism caused by injury to the stump of a leg that had been amputated the year before. Three hours after the injury there were dyspnœa, weakness, copious sweating and nausea, coma, a temperature of 39° to 40° C., and pulse of 120; death occurred on the following day. Autopsy showed no fracture, but fatty embolism caused by concussion. He believes that patients with bone injuries should not be subjected to transportation, massage, or tight bandages, and thinks that Wilms's method may be tried as a last resource.

American Cases.—Few cases of fatty embolism have been reported by American writers, and American literature contains but few allusions to the subject. The paucity of text-book discussions has already been mentioned. The great number of accidents occurring in this country with frequent injuries to the bones would indicate many cases of fatty embolism, and if such are observed and diagnosed it is strange that they are not reported. It is but just to infer that they are not recognized; and the deaths following fractures and amputations are probably often reported as the result of shock, "heart-failure," concussion, hemorrhage, pneumonia, sepsis, etc., when the real cause is fatty embolism. This has been the actual pathological experience of the writer, and must be true of medical practice in general.

Fitz[93] is the first American to report (1876) an undoubted case of fatty embolism in a case of Cabot's. The patient was a young laborer suffering from fracture of the upper third of the thigh, with extensive ecchymoses. A few days after the accident he became delirious, and died on the eighth day. His symptoms, in the main, were similar to those of shock. The lungs showed numerous fat-droplets; the brain was not examined.

Bailey,[94] in 1877, reported the case of a robust man, thirty-five years of age, having a punctured wound in the upper third of the left leg, but without fracture.

Eight days later he began to show nervous symptoms which could with difficulty be distinguished from those of acute alcoholism. Two days after he became delirious, with temperature ranging from 103° to 104° C. Beyond a slight cough there were no pulmonary signs; severe diarrhœa at the close. Death thirteen days after injury. Examination of lungs, liver, and kidneys showed capillaries filled with fat-droplets; this was regarded as the result of injury to superficial tissues. Pus, however, was found in the wound, and the case may have been one of septicæmia rather than embolism.

In 1878 Fitz reported a second case in a laborer who had been run over by a hand-car. The hip was dislocated, and there was extensive hemorrhage into the tissues of the thigh. No fracture was found. He died eleven hours after the accident with the symptoms of chill, cyanosis, dyspnœa, and heart-failure. The pulmonary vessels were found to be filled with fat-droplets.

In 1879 *Fenger* and *Salisbury*[95] reported the case of a woman, aged forty-five, who had fractured the upper part of the left femur in a fall. On the second day after, she had slight spasms, became comatose, face pale, lips slightly bluish. On the next day loud, coarse râles were heard all over the lungs. A clinical diagnosis of fatty embolism was made by Dr. Fenger. This was confirmed by autopsy, death having occurred on the third day. Multiple capillary fat-emboli of the lungs were found, and ecchymoses were present throughout the brain and beneath the pleura. No pus found in the fractures. In this article there is a reference to a case reported by Merriman in the *Medical Record*, 1879. This reference could not be verified, nor any trace of the report found.

In 1881 *Fitz*[96] also reports a case of lipæmia and diabetic coma in which the pulmonary vessels contained a small number of fat-emboli. He refers to the similar cases reported by Sanders, Hamilton, and Starr, but does not believe that the emboli in his case were sufficient to cause any symptoms. In the same journal *Cabot* reports a case of recovery from "traumatic coma" in a youth of twenty-four with comminuted fracture of left leg.

Starr,[96] in 1880, reported a case of diabetes with lipæmia and fat-embolism dying in coma. Fatty emboli were found in the lungs, kidneys, and liver.

Brown,[97] in the same year, reported the case of a boy, sixteen years old, dying of diabetes with marked symptoms of "air-hunger." On autopsy a white substance, thought to be fat, was found in the pulmonary artery. The diagnosis is very doubtful; it is probable that the white substance was only a lardaceous clot.

Claussen,[98] in 1881, reports a case of fracture of the thigh in a man aged twenty-five. On the fourth day he complained of headache and dizziness, the temperature rose to 101.5°, followed by delirium with rapid breathing. Death two days later. The autopsy showed fractures of pelvis and femur. Portions of the lung examined by Dr. Fenger showed marked fatty embolism. The brain was not examined.

In 1884 *Park*[99] reported two supposed cases, but without autopsy demonstration, and another case, a male, aged forty-one, with fractures of tibia and femur and extensive laceration of the soft parts, who became comatose after operation, and died twenty hours after. Autopsy showed free fat in the heart's blood, and fat-emboli in the pulmonary vessels. Of the two suspected cases, one is of especial interest as following an operation for cancer of the breast in a very fat woman. During the operation it was noted that the venous oozing was free, and that the fat-tissue "seemed to melt down." The patient became comatose

after the operation, and died six and a half hours later. No autopsy obtained. While the diagnosis is doubtful, Park held that the case was most probably one of fatty embolism. This case is similar to one reported in the writer's series.

Bonine and *Belknap*,[100] in 1886, reported a case in a male, aged fifty, suffering from fracture of the right femur as the result of a fall. On the seventh day insomnia, nervousness, and general mental disturbance developed. Temperature range, 101° to 103°, delirium and cyanosis. Some diminished resonance over lungs. After ten days the man began to improve, and recovered slowly. Free fat-droplets were found in the urine, and this finding forms a basis for the diagnosis of fatty embolism. The description of the urinary findings does not, however, remove the case wholly beyond doubt.

Whitney,[101] in 1892, reported an observation on a male, aged sixty-two, with a fracture of the right femur. On the third day dyspnœa, restlessness, vomiting, and a temperature of 101.5° developed. Autopsy imperfect. Pulmonary capillaries were filled with a highly refracting substance thought to be fat.

Bard,[102] in 1894, reported a similar case of recovery from fatty embolism, but the diagnosis is not substantiated.

Graham,[104] in 1907, reported very fully the case of a male, aged eighteen, who had been struck by a sled. After the accident the patient could not even rise. Mental condition was good, and there was no evidence of cerebral injury. Contused wound over the crest of the tibia. Temperature 101°, pulse 90. Lower third of left leg fractured. On the next day temperature range 101.5° to 104°, and complained of malaise. Next day comatose, and died two days later. Temperature before death 105.5°, pulse 164, respirations 60. Autopsy showed pinpoint ecchymoses of skin, brain, thymus, heart, and lungs (subpleural). Yellowish areas throughout heart muscle. Microscopically, multiple fat-emboli were found in the capillaries and smaller arterioles of all the organs, but most abundantly in the heart, lungs, spleen, kidneys, pancreas, and brain. In the heart and brain perivascular hemorrhages and areas of degeneration were seen. Fatty degeneration of ganglion-cells, muscle-cells, and liver-cells was observed in the neighborhood of the fat-emboli.

Graham also performed a series of experiments in rabbits; he observed fatty degeneration of the diaphragm in fatal cases of fatty embolism, and concludes that these lesions may in part account for the respiratory disturbance always observed. He found that the line of demarcation between fatal and non-fatal amounts of fat is ill-defined, individual susceptibility appearing to vary widely. An amount of fat which would be fatal if suddenly injected into the blood stream produces no unfavorable symptoms if introduced in divided doses at intervals of several days, such fat being eliminated by the kidneys and by the phagocytic action of the leucocytes. He distinguishes two lesion complexes—a pulmonary due to extreme blocking of the pulmonary vessels with less marked involvement of those of the heart, and the second as the result of a widespread embolism of the entire circulatory system, the pulmonary lesion being overshadowed by lesions of the heart, kidneys, and cerebral nervous system. In the first class, death is from asphyxia, and follows closely upon the trauma or disease which led to the entrance of fat into the vessels. In the second class, it depends upon multiple cerebral emboli, associated with embolism and fatty degeneration of the heart. In these cases death takes place only after the lapse of three to eight days.

Graham gives a very good review of the literature with an analysis of the leading features of fatty embolism. He calls attention to the increase of tem-

perature in his own and other reported cases in contradiction of Scriba's dictum that there is always a lowering of temperature in typical cases. He also calls attention to the occurrence of fatty degeneration of heart muscle as deserving especial consideration, although other authors, particularly Colley, have also insisted upon its importance. The persistence of the thymus gland in his case coincides with the views of Payr, Ahrens, and Colley that a status lymphaticus exists in cases of fatal fat-embolism following brisement forcé.

Neither Graham's case nor his experimental work contributes anything new to the pathology of fatty embolism, unless it be the observation on the fatty changes in the muscle-fibres of the diaphragm. Scriba, however, reported the finding of fatty emboli and capillary apoplexies in the skeletal muscles. Graham found none in the latter.

Carrington,[109] according to the quotation given by Le Conte and Stewart, collected 276 cases of fatty embolism, only forty of which were confirmed by proper autopsy—the only other writer to mention the presence of fat in the sputum as a diagnostic sign, which he found in six cases.

McCracken[110] writes a paper, general in character, emphasizing the importance of fatty embolism after comminuted fractures and on the operating table, but says it is probably exceedingly rare. No new cases.

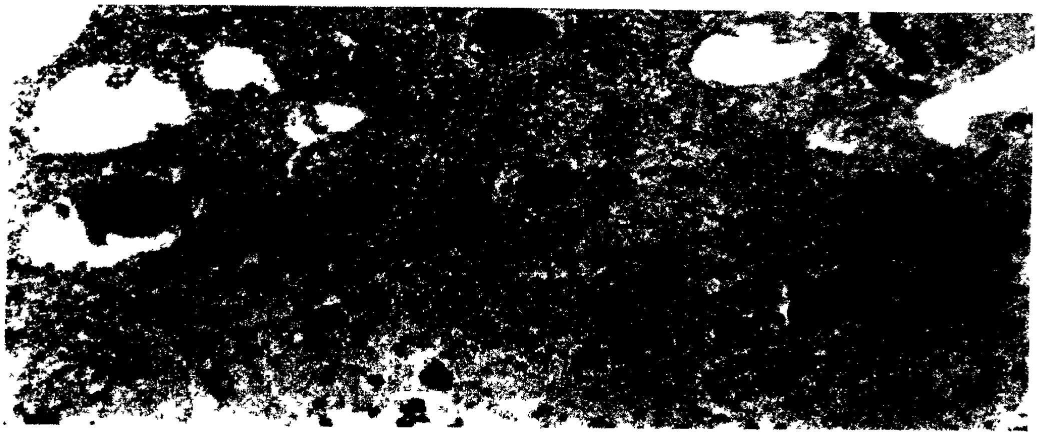
Field[125] reports a case of fat-embolism appearing in a patient suffering from chronic osteomyelitis after a ride of fourteen miles over a rough road. The patient developed cyanosis, dyspnœa, cardiac weakness, and coma, with fat in the urine. Recovery was slow, with intermittent attacks of dyspnœa and lipuria. Final result not known, as patient was lost sight of.

Other articles in American surgical text-books or systems are poor, and report nothing new since Scriba's paper. There seems to be a general failure among American surgical writers to recognize the importance of fatty embolism.

In addition to the cases collected from the literature, as given in the above historical survey, the following thirteen cases from my own pathologic laboratory are given in condensed form, as follows:

1. Case of fracture.
2. Amputation.
3. Concussion and fractures.
4. Injury to fat-tissues.
5. Fractures.
6. Injury to fat-tissues.
7. Fractures and concussion.
8. Fractures and concussion.
9. Fractures.
10. Fractures.
11. Concussion.
12. Injury to fat-tissues. Portogenous. Not fatal.
13. Extensive burns of skin.

FIG 1

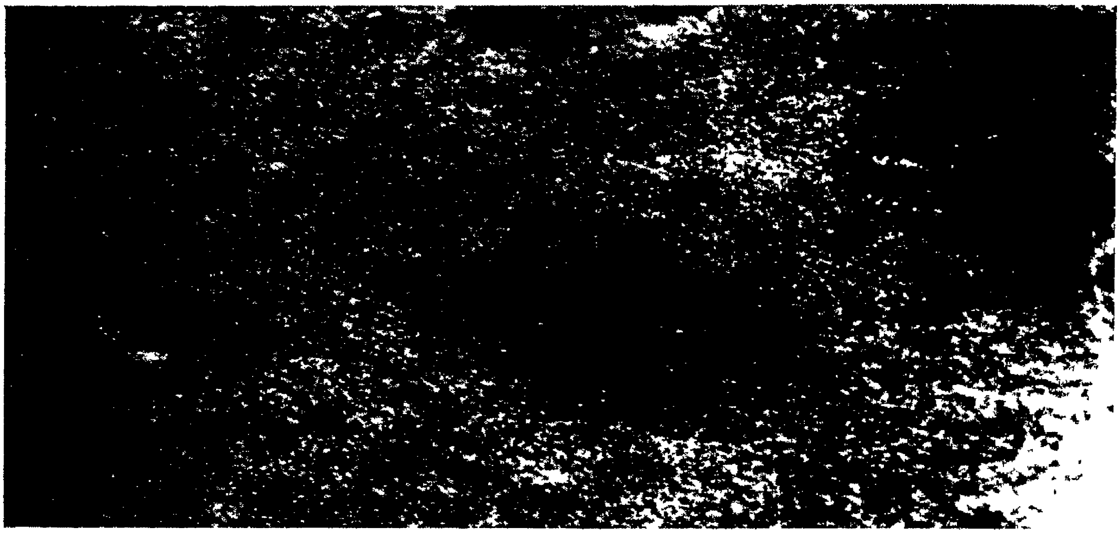


Lung from case of fracture of femur Death three days after injury. Osmic acid fixation Unstained

FIG 2.

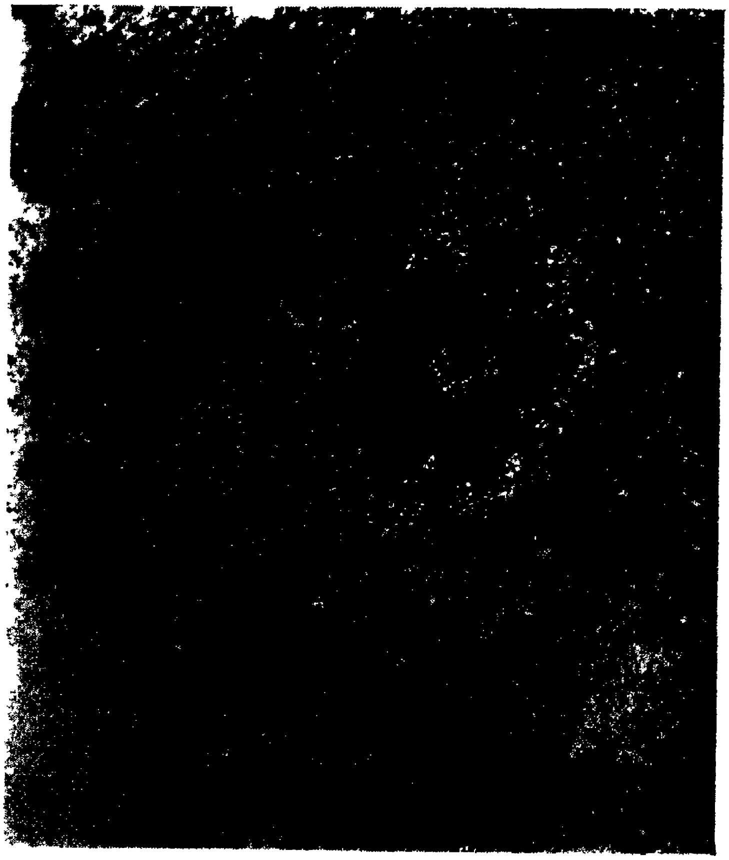
Lung from case of fracture of tibia Death three weeks after injury. Osmic acid fixation. Unstained.

FIG 3.



Multiple capillary hemorrhages in brain, due to fatty embolism. Fracture of both legs Death ten hours after injury. Symptoms suggested large meningeal hemorrhage Patient trephined. No hemorrhage found. Formalin fixation Hæmatoxylin and eosin stain

FIG. 4



Small perivascular hemorrhage from brain of same case as in Fig 3. Low power.

Following are the condensed protocols of these cases:

ORIGINAL CASES

CASE I.—Man of forty-five years, fracture of left femur. On the third day developed mental disturbances, dyspnœa, fever, pulmonary œdema, and weak irregular heart. Fat-droplets in urine and *in sputum.* (Fig. 13.) Numerous phagocytes containing large droplets of fat found in sputum. Small amount of free fat in urine. Became comatose and died in twelve hours.

Condensed Protocol.—Cyanotic skin, marked hypostasis, foamy fluid from mouth Marked pulmonary œdema, small hemorrhagic infarcts in lung. (Fig. 1.) Subendocardial ecchymoses. Large yellowish clot in right heart, made up largely of fat, extending into pulmonary artery. Right heart greatly dilated. Small bleeding points on cut surface of brain. Other organs show marked passive congestion. Microscopic examination showed numerous fatty emboli in lung with marked hemorrhage and œdema. Fat-emboli found in all organs. Small capillary apoplexies and areas of degeneration throughout brain. Areas of fatty degeneration in heart and liver, surrounding plugged capillaries.

CASE II.—Male, age forty-five to fifty, amputation of femur. On third day developed severe dyspnœa and pulmonary œdema. Sensorium clear, but patient was very restless. Temperature 102°. Died in ten hours. Lather-like fluid running from mouth; contained fat-droplets and phagocytes containing fat-droplets. Urine not examined.

Autopsy Protocol (condensed).—Marked hypostasis and cyanosis. Right heart greatly dilated, and contained large, yellowish-mixed clot composed chiefly of fat. Pulmonary œdema and hemorrhage. Other organs showed marked passive congestion. Examination of stump revealed a large amount of fatty bloody fluid; no infection.

Microscopic examination showed extreme fatty embolism of lungs with much œdema and hemorrhage. Few emboli in other organs. Marked passive congestion. No thrombi or hemorrhages. Atrophy and beginning fatty degeneration of heart muscle.

CASE III.—German, aged sixty years. Buggy struck by train. Thrown some distance, striking on head and shoulders. Unconscious when picked up. Remained so through night, dying next morning. Rectal temperature 104°. Clinical diagnosis: Concussion, intracranial hemorrhage, fracture of skull. Temperature before death subnormal.

AUTOPSY PROTOCOL NO. III

Body.—Well built, no anomalies on skeleton. Length 157 cm. Skin slightly pale, no œdema. Moderate hypostasis over back, and numerous ecchymoses and small cuts over surface of body, largest one over the right cheek. Right inguinal hernia over which the skin is pigmented. Musculature in good condition. Small amount panniculus. Rigor mortis present throughout. No broken bones.

Head.—On left side of vertex there is an incised scalp wound two inches in length, and smaller bruises over scalp. No depression can be felt in region of cut on head. There is a large ecchymosis in skullcap over vertex. The cut in the scalp extends through the periosteum, which is adherent, tissues about the cut infiltrated with blood. There is no subperiosteal hemorrhage, and no external fracture of the skullcap. There is an ecchymosis over lower part of left temporal. The dura is adherent anteriorly. The skullcap is 4 mm. thick, and is very thin over the pacchionian bodies, which are hypertrophic and dark-red in color. The lamina vitrea is dull and rough throughout. There is no fracture in the skullcap. The dura is thickened with about normal tension. The floor of the longitudinal sinus is filled with hypertrophic and deep-red pacchionian bodies, but contains no clots. There is a subdural extravasation on the right side about 1 inch by 1½ inches wide, the clot clinging to the dura. The dura is more adherent than

normal along the longitudinal sinus. There is a large clot over the left half of the tentorium. The pial veins are greatly congested. Over the entire cortex, but most marked over the occipital lobe and the cerebellum, is extensive hemorrhage —the blood being chiefly in the subarachnoid space. Beneath the pia are found several fairly large-sized clots. Small areas of congestion are seen over the cortex, most marked over the left hemisphere near the longitudinal sinus. The carotids show a moderate atheroma, which is most decided upon the left side. The circle of Willis also is slightly atheromatous. The anterior and posterior horns of the left lateral ventricle are filled with fluid blood, and the same is true of the right ventricle. All the vessels of the brain are enormously congested. The cut surface of the cerebrum and cerebellum shows an increased number of bleeding points, but there are no hemorrhagic areas in the cortex, nor is there any hemorrhage into the basal ganglion or internal capsule. The hemorrhage seems to be entirely meningeal. There is a bloody exudate in the base of the skull which contains small clots.

Thorax.—Muscles dark brownish-red, rather dry, do not tear easily. The eighth rib is slightly ossified. The diaphragm on the right is at the fourth intercostal space, on the left at the fifth intercostal space. No fluid found in the pleural cavity, and no remains of thymus. The lungs are very voluminous, covering up the heart. The sternum and mediastinal tissues are negative. Apex of heart is inside the nipple line in normal position. The pericardial sac is not distended, and contains a normal amount of clear fluid.

The *heart* is smaller than the cadaver's right fist, and weighs 340 Gm. There is a large soldier's spot over anterior wall of right ventricle. The pericardium is smooth and shiny. The right heart is collapsed and empty, the left heart full. The left ventricle contains fluid blood only; the mitral orifice barely admits two fingers and its flaps are thickened; wall measures at its thickest point 20 mm. The aortic opening admits the thumb with ease, though the flaps are slightly curled and show some calcification. The right heart is empty, and the wall of the ventricle measures 5 mm. at its thickest part. The tricuspid orifice barely admits three fingers, and the flaps are thickened. The pulmonary valves are negative. The heart muscle is brownish-red and of normal consistency. Aorta shows slight diffuse arteriosclerosis.

Lungs.—The left lung is adherent throughout, the adhesions being easily torn; the right lung also is adherent, the adhesions being mostly tender and easily torn, but stronger over the base. The left lung is voluminous, the edges emphysematous. The visceral pleura is covered with old adhesions, especially over the base. The lung is pinkish-gray in color, with slight hypostasis and moderate anthracosis. The cut surface yields an abundant exudate filled with air bubbles. The bronchial glands are heavily pigmented, and one contains a calcified tubercle. The larger bronchi are filled with clear, foamy exudate containing fat. The larger vessels are negative. The right lung is very voluminous, and the visceral pleura is covered with old adhesions, which are most marked over base. The cut surface presents same appearance as the left. The large bronchi are completely filled with foamy exudate containing fat. The large vessels are negative, and the bronchial glands show the same pigmentation. In the small vessels free fat is found.

Abdomen.—No fluid in the peritoneal cavity. The sigmoid flexure is distended with gas, and lies in the median line between the umbilicus and the pubis. The amount of omental fat is small.

The spleen is of normal size and triangular in shape. Over the anterior surface the capsule is markedly thickened and hyaline-like, and is considerably thickened over the whole spleen. The pulp is dark brownish-red and bleeds feebly, the trabeculæ are increased, the follicles atrophic.

The ureters are negative; the bladder contains a quantity of clear yellow urine, and the walls are thickened.

The duodenum is negative, also the bile-passages.

The stomach is dilated and contains partly-digested food. Postmortem digestion has already begun. The small intestines are negative, and the appendix normal. The large intestine and rectum are negative. About two inches of small intestine are in right hernial sac, and easily removed. The liver is atrophic but

swollen; it is soft, and its capsule stretches and tears easily. The cut surface is yellow in color and presents a fatty shine, is moderately rich in blood. There is a cavernous angioma in the right lobe. Liver lobules do not show distinctly. The gall-bladder is enlarged and full of bile. The mesenteric glands are slightly enlarged, and two of them hemorrhagic. The tunics of the testicles are thickened, and there is a double hydrocele.

MICROSCOPIC FINDINGS

Fatty emboli in capillaries of lung only. Passive congestion of all organs. Marked œdema of lungs.

Case regarded as one of fatty embolism due to violent concussion of all the bones.

Case IV.—Female, aged forty-nine, cancer of breast. Removal of gland with minute dissection of axilla. Patient very fat. Adipose tissue very soft and crumbling. Seemed to "melt away." Contained numerous bleeding veins. Oil-droplets in great numbers ran from wound. Twelve hours after operation became delirious and comatose. Very rapid and feeble heart. Signs of marked pulmonary œdema. Foamy fluid containing fat-droplets ran from mouth. In urine drawn by catheter without lubricant numerous fat-droplets were found. Died on the next day. Autopsy refused. Clinical diagnosis of fatty embolism borne out by fat-droplets in urine and sputum. At death the wound contained half a pint of slightly blood-stained oil. Temperature before death rose to 101°.

Case V.—Mr. W., a farmer, about forty years old. The bones of the left leg were shattered by the premature explosion of a blast. He did well at first, then became restless and apathetic, at times falling into a stupor, and had attacks of dyspnœa with marked fall of arterial pressure. His temperature ranged from 101° to 103°; his skin was pale, sometimes cyanotic; the sensorium dull and reflex excitability diminished. When dyspnœic there was a flow of foamy mucus from the mouth. The wound showed no sign of being infected, but the clinical diagnosis was sepsis. Amputation of the leg was decided upon, and was performed at the middle of the thigh. The patient almost immediately fell into profound collapse with high temperature, dyspnœa, signs of pulmonary œdema, low arterial pressure, Cheyne-Stokes respiration, and coma, and died the next day, three weeks after the accident.

AUTOPSY PROTOCOL

General External Examination.—Body well nourished, with good supply of fat and well-developed muscles. The skin was in fair condition; there was no œdema and but moderate hypostasis over back. The right thigh had been amputated at about the middle, the stump was covered with surgical dressings, and was not examined. The upper extremities showed slight rigor mortis. There was no body heat.

Internal Examination.—*Head.*—No scar or depression was seen in periosteum or skullcap. The pacchionian bodies were unusually large. Examination of meninges was negative, as were also base and interior of brain, with exception of numerous pin-point hemorrhages. The spinal cord was not examined. The dura was negative.

On section the muscles were dark red, dry, and easily torn. There was no fluid in the abdominal cavity, and the position of the abdominal organs was normal. The diaphragm extended on right side to the fourth intercostal space, and on the left to the fourth rib.

Thorax.—There were fresh adhesions on right side of thorax which were easily detached, especially over the base, and old adhesions over the left apex, with only slight adhesions over the rest. No fluid was found on right side in pleural sac. The left lung showed an area of bronchopneumonia near base in lower lobe. The right lung was firmly adherent over base, and showed hypostatic congestion and a few areas of bronchopneumonia, but less marked than on left side. There was marked œdema in both lungs, and quite marked hypostatic con-

gestion. Fat-droplets were found in the sputum and in the pulmonary alveoli. The small arteries were filled with plugs of fat.

Heart.—Weight, 13 ounces. Pericardial fluid was only slightly increased and clear. White clots in the right auricle were very yellow and contained free fat. A mixed clot in the beginning of the pulmonary artery contained free fat. The heart muscle was a little brown and very firm. Valves were normal. The aortic valve showed slight thickening, as did the endocardium of the wall of the left ventricle. The heart was slightly hypertrophied.

Spleen.—Weight, 8¼ ounces. Enlarged, rather soft and dark, stroma increased, and showed a few unusually firm areas.

Left Kidney.—Weight, 5¾ ounces. Capsule was thick and adherent. Old cyst found under capsule. Cortex was atrophied, connective tissue increased, and kidney rather firm. There was slight degeneration, cloudy swelling, and fatty change.

Right Kidney.—Weight, 5½ ounces. The capsules were thickened and adherent, the cortex atrophied, and the kidney firm, showing cloudy swelling and fatty degeneration.

Adrenals.—Showed usual postmortem change.

Liver.—Weight, 4 pounds 4 ounces. Showed fatty degeneration and cloudy swelling. The central zone was pale; the lobules were distinct with fatty change in periphery. The liver was soft and flabby, tore easily, and had a cloudy, cooked appearance.

Pancreas.—Was grayish-yellow and unusually soft.

Intestines, stomach, retroperitoneal glands, and blood-vessels were negative.

The external genitals were negative. The bladder was slightly thickened, and the prostate much enlarged. The testicles were negative.

Microscopical Findings.—Fatty emboli in capillaries of lungs, kidneys, and brain; capillary hemorrhages in brain; œdema, hemorrhage, and bronchopneumonia of lungs; fatty degeneration and brown atrophy of heart; atrophy and fatty degeneration of liver. (Figs. 2, 8, and 10.)

CASE VI.—Woman, aged eighteen, delivered of twins at term, developed symptoms resembling eclampsia. Died three days after delivery. Symptoms were coma, convulsions, pulmonary œdema, and cardiac insufficiency. Temperature 104° to 105°, respirations 60, pulse 150, almost imperceptible.

Condensed Protocol.—Heart dilated, chicken-fat clots in right auricle and ventricle. Sub-epicardial and endocardial hemorrhages. Punctate hemorrhages and areas of fatty degeneration in heart muscle. Marked œdema, congestion, hemorrhagic infarction, and bronchopneumonia of lungs. Thyroid much enlarged; contained no colloid. Numerous bleeding points in cortex. Marked parenchymatous degeneration in kidney and liver.

Microscopic Examination showed the presence of *fat-emboli*, numerous placental cells, and bone-marrow giant-cells in lungs. Extreme œdema, congestion, hemorrhage, and bronchopneumonia. No fat-emboli found in any other organ, but brain showed numerous capillary hemorrhages and areas of beginning degeneration. Similar areas were found in the heart muscle. Kidneys and liver showed extreme cloudy swelling and fatty degeneration. Marked congestion of all organs.

CASE VII.—Male, tramp, age unknown, about forty, struck by train and thrown some distance. Fracture of left humerus and left femur, numerous contusions and lacerations. Was unconscious when brought to hospital. Died on the second day without recovering senses. Cheyne-Stokes phenomenon. Heart rapid, very weak. Low arterial pressure.

Autopsy Protocol (condensed).—Body very dirty, covered with lice. Vagabond's skin. Obscene tattoo marks on arms. Numerous cuts and bruises. Heart dilated, right side filled with large, yellowish chicken-fat clot containing free fat. Free fat-droplets in pulmonary vessels. Subendocardial punctate hemorrhages. Lungs showed marked œdema, congestion, and hemorrhages. Punctate hemorrhages in brain. Cloudy swelling and fatty degeneration of kidneys and liver. All other organs markedly congested. Focal areas of fatty change in heart muscle. Urine in the bladder covered with layer of oil.

Microscopic Examination.—Extensive fatty embolism of lungs, brain, heart, kidneys, liver, and all other organs. Areas of fatty degeneration about plugged-up capillaries. Minute hemorrhagic infarctions with beginning necroses in heart, brain, and striped muscles.

CASE VIII.—German, about forty-five years of age, mason, fell about thirty feet. Frontal and facial bones showed multiple fractures. Numerous large flesh-wounds. Multiple fractures of extremities and vertebral column. Became comatose shortly after the fall, and died about ten hours after. Clinical diagnosis, meningeal hemorrhage.

Protocol (condensed).—Multiple comminuted fractures of facial and frontal bones. Fracture-dislocation of spine at level of seventh and eighth dorsal vertebræ. Subperiosteal hemorrhage over frontal region. Meningeal hemorrhage. Large masses of yellow, fat-like cruor in right auricle. Œdema of lungs, which also showed small, rounded hemorrhagic areas. Large hemorrhage in posterior mediastinum. Microscopic examination showed numerous fat-emboli in lungs, with marked œdema, congestion, and hemorrhage. No emboli found in other organs. Yellow clot in heart composed chiefly of fat.

CASE IX.—M. A., male, age sixty-six, markedly senile. Slipped on icy pavement and fell, fracturing left femur—a comminuted fracture. Shortly after accident he became dyspnœic and cyanotic. Foamy, lather-like fluid ran in a constant stream from his mouth, and was occasionally blood-stained. He showed marked symptoms of shock, gradually became comatose, and died on the third day after the accident. Free fat-droplets in great numbers were found in the sputum, also numerous phagocytes containing great numbers of fat-granules. Urine showed no fat. Temperature, 102° to 103°. Clinical diagnosis was pneumonia following fracture of femur.

AUTOPSY PROTOCOL

General External Examination.—The body was 170 cm. long, and was large with large chest. The epigastric angle was wide, the abdomen distended below the umbilicus. The left leg was rotated outward and shortened, the thigh swollen and œdematous. There was distinct crepitus, the upper fragment overriding the lower. Section of thigh showed fracture of shaft just below trochanter, also two smaller fragments, and about 500 Cc. of semi-fluid, grayish emulsion of fat escaped from surrounding tissues. The skin was pigmented over arms; the hair fairly abundant, the beard abundant and gray; the musculature fair; the teeth absent in upper jaw, a few decayed ones below. No rigor mortis. Panniculus was moderate over abdomen—pale yellow on section. There were small, pultaceous masses in left, also small cyst; in fat of right side was small body resembling lymph-gland. The scrotum was œdematous. There was no body-heat. A greenish discoloration over the abdomen. The superficial veins were congested. The skin over the abdomen showed subcutaneous nodules, and there were small erosions over left side covered with scabs. The left thigh showed extravasation of blood.

INTERNAL EXAMINATION.—*Head.*—The scalp was negative, the periosteum negative except for thickening over parietal cones. The skullcap was removed only by cutting dura; in postparietal region was an area of depressed bone 15 mm. in diameter which was discolored and showed bleeding vessels. Outer table was eroded, probably from cephalhæmatoma at birth. Dura was adherent all over convexity. The longitudinal sinus contained soft, currant-jelly clots, white clot, and fluid blood; had odor of putrefaction. Basal sinuses contained currant-jelly clots and fluid blood. Inner meninges showed thickened adhesions between dura and arachnoid. Anterior cerebral artery showed sclerosis. Frontal lobes showed atrophy, congestion, and œdema. Lateral ventricles were dilated. Pineal gland was softened and disintegrated. The left vertebral artery was dilated, the basilar sclerosed. Weight of brain, 1400 grammes.

Thorax.—Diaphragm reached to fifth rib on right, same on left, and was

arched downward on both sides. Apex of heart was behind sixth rib inside nipple line. Pleural cavities contained small amount of fluid. Pericardium was deeply stained with blood.

The *heart* was very large, soft, and flabby, and weighed 585 grammes. Both ventricles were dilated. Subepicardial fat was increased. Right auricle contained large agonal clot; was greatly dilated. Anterior wall of right ventricle showed soldier spot. Ventricle contained very large chicken-fat clot showing fat-droplets. Heart muscle was soft, tearing easily. Valves of the heart were negative, except that aorta showed beginning sclerosis. Heart measured 13 x 14 x 6 cm.

Left lung weighed 750 grammes, measured 26 x 19 x 5 cm. Was free except for small adhesions over lower lobe, which was rather voluminous and showed marked anthracosis. Border emphysematous. On section cut surface was moist. Pressure produced abundant cloudy exudate containing fine fat-droplets. There were elevated, slightly granular airless areas around small bronchi. Œdema was present. *Right lung* was free except for slight adhesions over lower lobe; similar in all respects to left. Weight 1170 grammes, measured 29 x 19 x 6 cm.

Fatty globules were found in lungs; frozen section stained with Sudan III showed marked fatty embolism.

The chicken-fat clot in right ventricle extended into pulmonary artery.

The smaller bronchi showed purulent exudate with distinct fat-droplets.

Aorta was dilated and showed arteriosclerosis and atheroma, with atheromatous patches in intima.

Trachea was of unusual size, congested, and filled with mucus containing fine fat-droplets.

Abdomen.—Abdominal cavity contained no fluid. Peritoneum was moist and shining. Omentum was moderately rich in fat, with congested veins. The lower border of the liver was low.

The *spleen* was very small and soft, with wrinkled and thickened capsule. On section the splenic pulp was atrophic, congested, and its stroma increased. Weight of spleen, 90 grammes; measurements, 10 x 7½ x 2 cm.

Left adrenal showed complete postmortem degeneration.

The *left kidney* showed retention cyst. On section was atrophic, the labyrinths swollen and cloudy, the blood-vessels congested. Weight, 230 grammes; measurements, 12½ x 6½ x 5½ cm. Cortex measured 3 to 4 mm.

The *right kidney* showed several retention cysts in cortex. The venæ stellatæ were engorged, the consistency diminished. Kidney had same appearance as left on section. The pelvis was dilated. The fatty capsule was abundant in both kidneys.

The folds of the *duodenum* were atrophic.

Pylorus was patent; admitted finger easily. There was a strong odor of H_2S in stomach. Mucosa of stomach showed complete postmortem digestion.

The *small intestine* was distended.

The *appendix* region was negative, appendix lying behind cæcum.

The *cæcum* was moderately distended, also colon.

The *liver* was three finger-breadths below ensiform in right nipple line, 2½ finger-breadths below nipple. Liver was soft, and showed cavernous hæmangioma. On section had appearance of nutmeg liver. Weight, 2120 grammes; measurements, 27 x 21 x 8 cm.

The *gall-bladder* was distended, and contained a number of small faceted gall-stones, chiefly cholesterin.

The *portal vein* was distended with thick, fluid blood.

The *pancreas* was atrophic, congested, and soft; showed postmortem digestion.

The *retroperitoneal lymph-glands* were atrophic, and vessels of this region were atheromatous.

Male Sexual Organs.—External examination of penis was negative. Scrotum was congested, macerated, and scaly. Tunics of right testis were thickened with increase of fluid between; the body atrophic. Left testis similar to right. Epididymis showed a number of cysts about the size of a pea. Prostate was about normal size; on section was negative.

MICROSCOPIC FINDINGS

Lung.—Frozen section stained with Sudan III shows marked fatty embolism of capillaries. Excessive sclerosis, healed tubercles, emphysema, œdema, congestion, a few areas of pneumonia. Free fat in sputum.

Liver.—Atrophy, chronic passive congestion, some fat-emboli, postmortem change, fatty infiltration.

Thyroid.—Marked atrophy.

Fat-emboli found in all organs; not so numerous as in lungs. Focal necroses and hemorrhages in brain and heart.

Pathological Diagnosis.—Bronchopneumonia, œdema, fatty embolism of all organs.

CASE X.—B. R., motorman, age twenty-seven, both legs crushed in collision. Was removed to hospital and wounds dressed. He did not recover from anæsthetic; became restless, delirious; temperature was subnormal; showed loss of reflexes; coma increased with Cheyne-Stokes phenomenon. Heart was very feeble and rapid. Foamy fluid discharged abundantly from mouth, and was afterward found to contain free fat. There was no examination of urine for fat. After consultation surgeons trephined for meningeal hemorrhage, but no blood was found. Coma gradually deepened, temperature rose rapidly to 106°, and death took place about ten hours after the accident.

AUTOPSY PROTOCOL

General External Examination.—Body was 160 cm. long, well nourished. Skin was yellowish-white; greenish-blue over legs, with some dark spots. Teeth were good. Rigor mortis was marked; œdema in left leg; panniculus good. The conjunctivæ were clear. There was beginning hypostasis, and over the trunk were numerous petechiæ.

In right parietal region of head was a semicircular incision 8 cm. long with gashed edges. Within the hemisphere of this was another cut 2 cm. long. The cuts were closed with the exception of a drain in the larger which led directly to a trephine opening 4 cm. in diameter lying under the smaller gash. Through this opening protruded the brain substance,—soft, bloody, and suggesting pus. Edges of the wound were clean with exception of slight gray film.

There was a fresh abrasion, 2 x 4 cm., over right trochanter, and one over left, 1 x 2 cm. Legs were swollen. Left leg showed numerous abrasions. Crepitus was felt corresponding to abrasion over tibia. The leg could be bent at this point. Foot was normal but for dark-blue spots mentioned above. Right leg showed jagged wound over tibia on inside at junction of upper and middle third, 3 x 3 cm., through which bone protruded, and beneath skin anteriorly could be felt a splinter freely movable. Lower leg hung free; shortened as compared with the left. Over inner and outer aspects of right knee were large, superficial abrasions, outer 1 x 6 cm., inner 7 x 5 cm. On right side were two areas, one 4 x 2 cm., and light purplish, other 7 x 3 cm., similar in color but desquamated. Upper leg normal.

Head.—The scalp was thick and showed œdema about wounds. Six centimetres above left ear was another purplish spot corresponding with subperiosteal extravasation of blood. There had been bleeding under temporal muscle. Hemorrhage about wound extended back to occipital region. Firmly adherent posteriorly, the dura was otherwise free. Beneath dura the brain was covered with a hemorrhagic exudate. The longitudinal sinus was empty. Inner surface of dura away from opening was clear. Pia was slightly adherent over pacchionian bodies. Sinus at base of skull was free from hemorrhage. The membranes were torn away over wound, and brain substance bulged through opening. The pia was clear except for slight adhesions at base, and veins were congested. There was slight hyperæmia at base of brain. The vessels were free from sclerosis. The right hemisphere was lacerated, and showed hemorrhage through the area of laceration with softened tissues to a depth of 2 cm. This laceration involved upper part of second temporal and margin of first temporal convolutions. The

convolutions were a little flattened. The white substance was covered throughout with many punctate hemorrhages. The brain substance was greatly congested, and there was diminished consistency of brain tissue.

The cerebellum showed similar hemorrhages in the white substance and some in the gray. The brain stem showed scattered punctate hemorrhages in left external capsule and in anterior part of interior capsule. Section through optic thalamus on each side showed two red areas, each 2 mm. across, with slightly depressed centres surrounded by margins in which the tissues were congested.

Thorax and Abdomen.—Diaphragm on right rose to level of fifth rib. Abdominal cavity contained no free fluid; intestines were moist. The mediastinum contained fat. There was no trace of thymus. The pericardium was smooth and contained about 25 Cc. of fluid.

Heart.—Measurements, 12 x 9 x 6 cm. Apex of heart was in mammary line. Heart was firm. The surface glistened over anterior part of right ventricle, to less extent over left ventricle, on which were small, bright-red pin-point spots. Everywhere over endocardium were bright-red spots. Scattered throughout myocardium were a few red points and numerous yellowish areas. Auricles were not dilated. The right ventricle contained some soft clot, the left a little fresh clot. The left ventricular wall was 4 cm. thick. Aortic valve was competent to water test; the flaps were thin. The mitral valve was not thickened, and its orifice was 1 cm. in circumference. The pulmonary valve was delicate, but otherwise negative.

Lungs.—Left lung sunk back evenly on opening thorax, and showed no adhesions. There were large reddish areas, and several black irregular pigmentations. The lung crepitated everywhere. The mucous membrane was smooth, pinkish-white. Bronchi showed frothy fluid containing fat-droplets. Veins contained fresh clot of blood, and arteries a little fluid blood. Lung on section was pink, and filled with frothy pink fluid. Right lung was voluminous with moist, dark-red surface mottled with bright-red, small superficial areas 2 to 4 mm. in diameter; some larger ones on posterior surface of lower lobe. The veins were empty; the arteries contained little fluid blood. The lung substance crepitated everywhere except in lower lobe, and on section was full of frothy fluid. The bronchi were filled with frothy, bright, bloody fluid. The mucous membrane was smooth and pinkish-white. The bronchial glands were swollen and red.

Mouth and Neck.—The tongue was smooth, gray-white, and dry. Tissues back of tongue were hyperplastic. Tonsils were large, showing irregular clefts, and were gray on section. Left tonsil contained several small cysts holding pus-like fluid. Larynx was smooth, and empty except for slight mucus. Trachea was empty, the mucosa showing some smooth superficial red spots. Œsophagus was negative. Thyroid measured 4 x 3 x 2 cm.; its cut surface was pinkish-red, and showed no colloid.

Abdomen.—Peritoneum was glistening; no pin-point areas above described.

Spleen.—Measured 12 x 7½ x 3½ cm., weighed 125 grammes. Spleen was large, dark purple, free, and smooth, with a few raised whitish areas suggesting connective tissue. The cut surface was smooth, moist, bright red, and trabeculæ distinct.

Adrenals.—Left measured 6 x 2 x 5 cm., weighed 8 grammes. Medullary substance was easily distinguishable, pale, firm. Right measured 5½ x 3½ x ½ cm., weighed 10 grammes; was firm, like left.

Kidneys.—Left measured 11 x 4½ x 4½ cm., weighed 140 grammes; was surrounded by a moderate amount of fat. Capsule stripped easily. Venæ stellatæ were moderately congested. Cortex was pale, 5 mm. thick, vessels here and there being injected. Right measured 10½ x 5¾ x 4 cm., weighed 138 grammes; was similar to left. In left side of pelvis near sacrum in retroperitoneal tissue was a dark-red area of diffused hemorrhage into mucosa.

Bladder.—Was distended with 800 Cc. of straw-colored urine. The wall was flaccid and grayish-white, with here and there red pin-point ecchymoses.

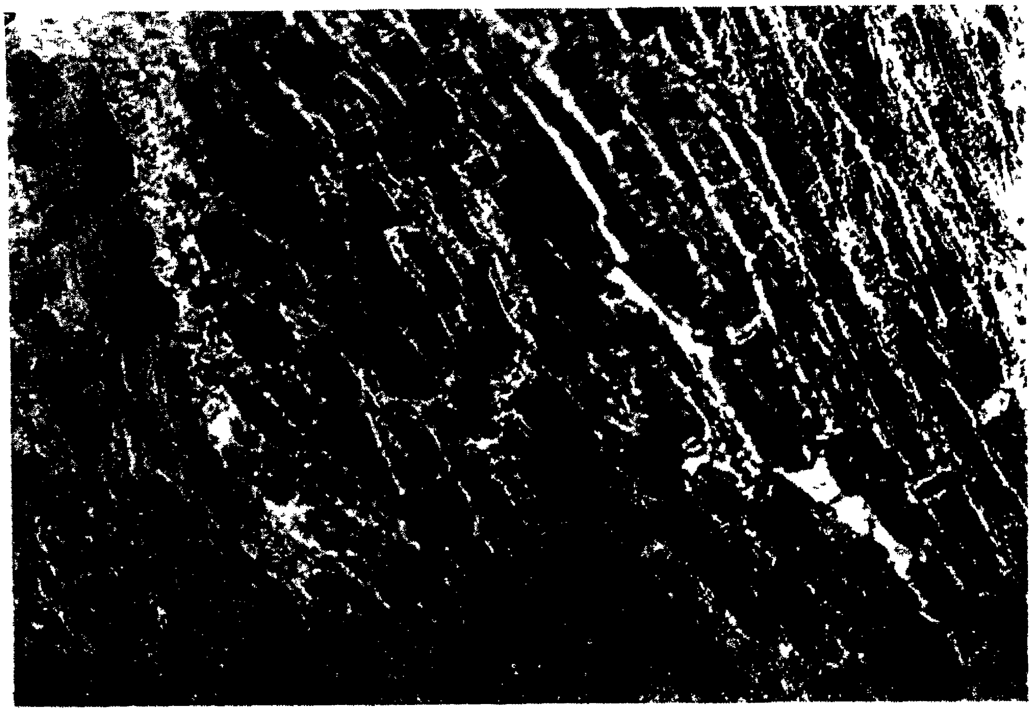
Stomach.—Duodenum was empty. Stomach contained about 500 Cc. of grayish-brown fluid. The walls were smooth and not swollen, the mucosa was normal, and the submucous vessels could be seen.

Small Intestine.—Was collapsed, jejunum was empty except for a little light-

Fig 5

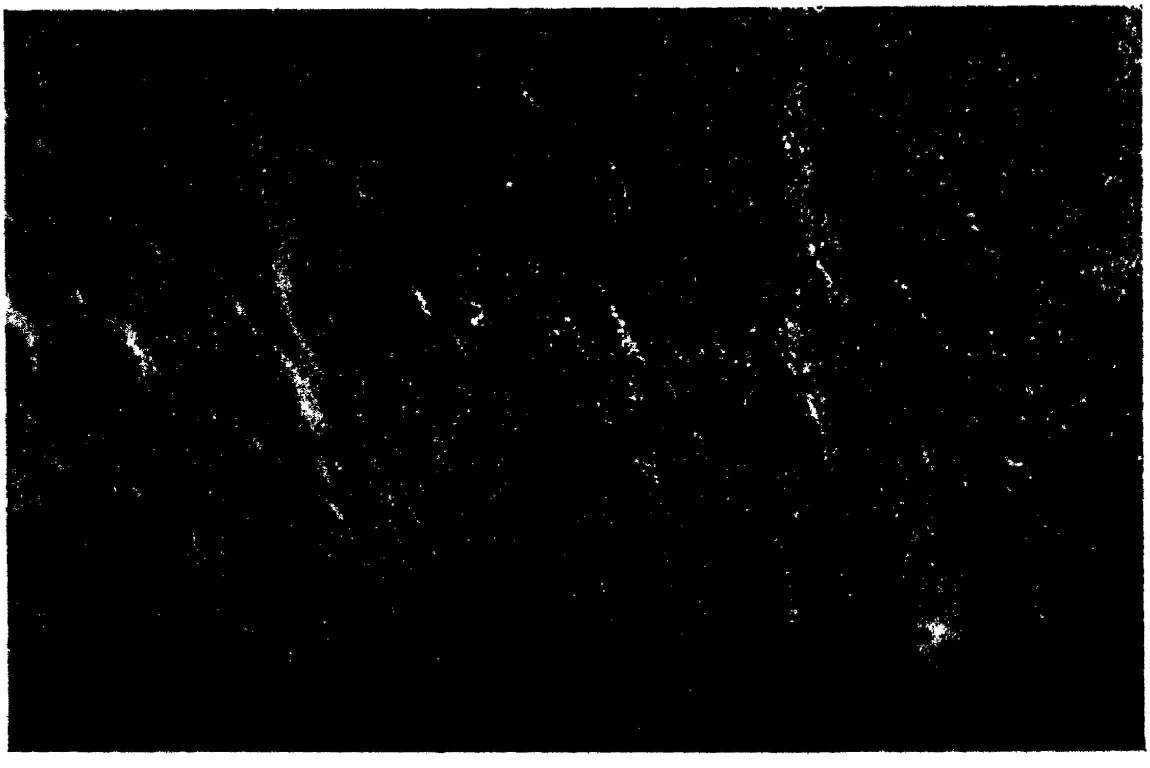
High-power view of same perivascular hemorrhage in brain as in Fig 4. Area of central necrosis. Small anæmic infarct with hemorrhagic zone

FIG 6.



Small infarct in heart-wall due to fatty emboli, showing fatty degeneration of muscle of anæmic area The injured heart-muscle takes up the fat from the plugged-up capillaries Small hemorrhage in and about these areas of fatty degeneration. From case of fracture of both legs, patient dying ten hours after injury

FIG. 7.



Photograph of area of fatty degeneration and fatty embolism from heart-wall of same case as in Fig 6. Sudan III and hæmatoxylin stain of frozen section.

brown fluid. The mucosa was pale and smooth. In the mesentery, 300 cm. below duodenum and between folds at insertion to intestine, were a number of clear yellowish, translucent cysts.

Large Intestine.—Was smooth and injected, and contained little mucus; otherwise negative.

Appendix pointed to right anteriorly and was 10 cm. long.

Liver.—Weight, 1550 grammes. Was not enlarged; surface was injected, bright red, smooth, and glistening. Cut surface was pale and regular. The bile-passages contained bile. A small quantity of blood oozed from cut vessels Here and there on cut surface were light yellowish areas, irregular in outline, glistening and raised, 3 x 4 cm. Liver structure within these areas was blurred, suggesting beginning fatty degeneration.

Gall-bladder contained about 40 Cc. of dark-brown bile, otherwise negative. *Portal vein* contained much fluid blood.

Pancreas was 15 cm. long, firm, with grayish-pink substance. Between pancreas and abdominal vessels was an extravasation 4 x 5 cm.

Retroperitoneal lymph-glands were not enlarged.

Aorta was smooth, elastic everywhere, and contained small amount of fluid blood. The walls were delicate Vena cava was nearly empty.

Male Pelvis.—Right testis was small and soft, cut surface pink and moist; left was very small, similar to right. Tubules were easily seen and regular. The prostate was not enlarged, and the cut surface was smooth.

Abdominal muscles dark red on section. On section muscles of right lower leg are found suffused with blood; upper fragment of tibia projects through skin-wound. A movable fragment of bone, crescent-shaped, 2 cm. long, between upper and lower fragments of tibia. No signs of pus. Fibula broken at same level Lower fragment passes upper posteriorly about 25 cm. Large effusion of blood through muscles of calf. Left fibula not broken. On cutting into muscles of calf similar large effusions are found. Fracture of tibia is V-shaped. No displacement.

Microscopical Findings.—Lung, fatty embolism, œdema, congestion, hemorrhage, pneumonia. Liver, cloudy swelling, fatty embolism, small localized areas of fatty degeneration and necrosis which are associated with larger areas of fat in the capillaries. Hæmatoidin in central zone. Kidney, fatty embolism, cloudy swelling, fatty degeneration. Brain, fatty embolism; surrounding the emboli are localized areas of hemorrhage, œdema, and fatty degeneration, these corresponding to small infarcts due to embolism Many of these hemorrhages are large enough to be seen by the naked eye. The smaller arteries leading to these hemorrhagic areas are completely blocked with fat, as is shown by Sudan III stain. All organs show fatty embolism with local areas of fatty degeneration, cloudy swelling, simple necrosis, and hemorrhage corresponding to small infarcts due to embolism. This is beautifully shown in the heart muscle and striped muscle, as in the diaphragm, the adrenals, and other organs. In the striped muscles, particularly in the diaphragm, muscle-fibres nearest to the large fatty emboli show marked fatty degeneration. (Figs. 3, 4, 5, 6, 7, 9, 11, and 12.)

CASE XI.—Male, aged forty, plasterer by trade. While intoxicated fell or was pushed down stairs. Broke both wrists and badly bruised head. Was taken to the hospital, where he did well for one week, then began to show mental disturbance. Temperature rose suddenly to 107°, was delirious, escaped from hospital in delirium, and was absent for two days. Marked dyspnœa, "air-hunger," and coma at the last. White foamy fluid like soap-lather ran constantly from mouth. Free fat-droplets in this. Sputum also contained numerous alveolar cells filled with fat-granules. Urine not examined for fat.

Autopsy by Coroner's Physician.—Imperfect. Lungs, liver, and stomach sent for examination. Fixed in formalin. On microscopic examination extensive fatty embolism of lungs. Few emboli found in liver, but the intralobular (central zone) fatty change gave evidence that the emboli had been dissolved out. Few fat-emboli in mucosa of stomach. *Coroner's diagnosis:* Acute alcoholism; fall not accountable for death. *Pathologic diagnosis:* General fatty embolism, result of fractures and fall; cerebral type predominating.

CASE XII.—Boy, aged eighteen years, marked adipositas, infantilism, and general picture of tumor of hypophysis. Attempted removal of hypophyseal tumor in prolonged chloroform narcosis. Boy struggled violently. Died on following day. Autopsy. *Pathologic diagnosis:* Infantilism; adamantinoma of hypophysis (hypopituitarism); lymphatic constitution; persistent thymus; hyperplasia of thyroid and medulla of adrenals; general lipomatosis; postoperative cerebral hemorrhage; fatty embolism of liver alone. Liver showed marked central and localized fatty degeneration, with numerous large fatty emboli distending the capillaries in various portions of the liver-lobules. Endothelium and liver-cells in the immediate neighborhood showed marked fatty change.

CASE XIII.—Miss R. M., aged eighteen, burned on both legs, thighs, back, and both arms; second-degree burns over two-thirds of body. Lived thirty-seven days. During this time showed intermittent attacks of stupor, air-hunger, lipuria, and pulmonary œdema with fat-containing sputum. Temperature very irregular, subnormal to 104°, usually 101° to 102°, pulse 100 to 140. Infusion of two per cent. sodium carbonate during one period of extreme dyspnœa relieved the air-hunger; further attempts not made. Pulmonary condition became more marked; appearances of bronchopneumonia. Autopsy showed a pulmonary fatty embolism, with a mould infection (aspergillus) of the bronchi, numerous hemorrhagic infarcts, hyaline thrombi, extreme congestion and œdema. Fatty embolism and pulmonary thrombosis followed by gangrenous bronchitis secondary to burns of skin regarded as cause of death.

EXPERIMENTAL

In spite of the fact that various writers have done a fairly large amount of experimental work with animals, a number of important points connected with fatty embolism need further elucidation. In the study of the human cases, the almost invariable presence of a dilated, paralyzed right heart containing large yellow, "chicken-fat" clots, made up chiefly of oil, led to a desire to see if the same condition could be produced experimentally.

Furthermore, the remarkable taking up of fat-droplets by the heart muscle, skeletal muscles, liver-cells, adrenal cells, splenic cells, etc., in the neighborhood of the emboli suggested an attempt to solve some of the problems connected with fatty degeneration and infiltration.

Rabbits, dogs, and chickens were used under the ordinary conditions of experimental work. Acid-free olive oil was employed in varying amounts; pure with one series of animals, and combined with Sudan III or Scharlach R. in another. The dye-oil was prepared in the same manner as that used in the experiments on regeneration or proliferation of epithelium.

Measured amounts of the oils were injected in different ways and into different vessels, according to the object desired. The tissues were either frozen directly and cut, or given a short preparatory fixation in four per cent. formaldehyde. When necessary, syrup or gelatin was used for imbedding before freezing. When the pure oil was injected the frozen sections were treated with osmic acid, Sudan III, or Scharlach R., counter-stained with hæmatoxylin, and mounted in glycerine.

A series of rabbits was first used to demonstrate the ordinary pathology of fatty embolism.

Experiments 1 to 6.—Six Belgian hares were injected with 4 Cc. of olive oil in the jugular. When injected rapidly this produces dyspnœa, muscular tremors, and slight convulsions leading to death in two to five minutes. Larger amounts cause death almost immediately. In these cases, on opening the dilated right heart, the ventricle and auricle contain soft friable masses of blood and fat-clot, usually filling up the ventricle and extending into the pulmonary artery. No matter how acute, fatty emboli are always present in great numbers in the lung, and occasionally in the organs of the systemic circulation. In the heart-wall itself a varying number of fat-emboli are found, but in these acute cases there is usually not much fatty degeneration. If the amount of oil is not too large, and

if the animal lives for some hours, the muscle-fibres around the fat-emboli gradually lose their nuclei and stain a faint red with Sudan III or Scharlach R., while the fat-emboli in the area of focal degeneration are a deep homogeneous red. Similar areas are found in the skeletal muscles of animals treated for a longer time. With the one dose, fat-emboli may be found in any part of the body, although the lung shows the majority of them. Injections into the ear-vein give the same results.

The main features, that is, the common ones, of fatty embolism as we know it in man, can be reproduced in this way. Fat-droplets appear in the sputum, and also pass into the renal tubules.

Experiments 7 to 12 Inclusive.—Six Belgian hares were given injections of olive oil in divided doses of .2 Cc. at different intervals of time from three to twenty-one days. As Graham found, it is difficult to fix an arbitrary minimum fatal dose. The individual variations in animals, apparently of the same general characteristics, are very great. Our minimum dose we found to be larger than the 1 Cc. per 1100 Gm. of weight as roughly stated by Graham. Four or six grammes in divided doses frequently did not produce great disturbance or show a temporary dyspnœa, but our animals were larger than those used by Graham, weighing 2500 to 3500 Gm. or more. Our results with divided doses spread over a greater period of time agree with this, and, as he has pointed out, give microscopic pictures much more closely resembling those of human fatty embolism. Numerous emboli occurred in the lungs, pulmonary œdema and hemorrhage were seen; the heart, brain, cord, spleen, liver, kidneys, skeletal muscles,—in fact, all the organs and tissues,—showed the presence of numerous fatty emboli. When the injections were spread out over a period of time exceeding a week, the pathological changes were very characteristic of the condition as seen in man. While the lungs showed the greatest number of emboli, they were abundant everywhere. The capillary hemorrhages and areas of necrosis in the central nervous system and heart-wall were precisely like the small hemorrhagic areas of necrosis in the same organs of man. In the diaphragm and skeletal muscles the fatty degeneration of the muscle-fibres about groups of capillaries was very striking. Graham found this change only in the diaphragm, and says it does not occur in the skeletal muscles. In this he is mistaken; it may be found anywhere in the muscle-fibres bordering upon plugged capillaries.

In many of the animals receiving larger doses divided and given at intervals, the emboli in the systemic circulation appear to be more numerous than in the lung. It would seem that the lung takes up a certain amount of the oil and holds it back, but that some always gets through; and when the injections reach a certain degree there is an overflow into the systemic circulation. The proportions found in different organs vary with given animals, just as the symptoms produced by the injections vary widely. Local conditions of current, blood-pressure, and, arterial resistance must have a great deal to do in determining the distribution.

As found by Graham and others, the fat is excreted in part by the kidneys, passing from the glomerular capillaries into the tubules. There is no evidence that the renal cells permit the fat to pass through. They never show the beautiful pictures of fatty degeneration seen in the muscles, liver-cells, and the cells of the adrenals and pancreas. A large amount of fat is also passed out through the lungs by way of the sputum. No one seems to have considered this avenue of escape, or to have used it as a means of diagnosis. As I shall show later, it is one of the earliest positive signs of fatty embolism.

It is apparent from animal experiments as well as from human pathology that the brain will stand a fairly large amount of capillary embolism before perivascular infiltration and necrosis occur. The gray matter may show great numbers of pure capillary emboli without any discoverable pathological changes; but as soon as these capillaries become more dilated, and a cord of fat extends farther back toward the longer branches and arterioles below, then other capillaries not containing fat show marked congestion, stasis, and thrombosis, with areas of degeneration and necrosis that quickly become filled with blood by diapedesis through the injured vessel wall. These small hemorrhages are nothing more than small hemorrhagic infarcts. The necrosis or degeneration occurs first; the hemorrhage is secondary.

A large part of the fat must be used up in the liver. Wherever there is a blocked-up capillary the neighboring liver-cells become filled with fat-granules and their nuclei stain less well, and finally the cell may become necrotic. The endothelium of the liver capillaries and the "Sternzellen" take up the fat first, and then pass it to the liver-cells. In an early stage the liver-cells may contain no fat, while the endothelium lining the intralobular capillaries appears as if set with minute beads. Sudan III and Scharlach R. sections of material from experimental animals present many beautiful examples of cell-activity.

Experiments 13 to 18.—These were carried out with injections of Sudan oil, given in the same way and in the same doses. The tissues are thus filled with an oil already dyed, and only the hæmatoxylin is needed to produce most beautiful pictures. In many ways the appearances thus secured are superior to those obtained by injecting the pure oil and staining the sections. We found, however, that the dye-oil causes a good deal of intravascular coagulation and thrombosis, particularly in the heart. A rapid injection of 2 to 3 Cc. of the dye-oil would often cause immediate death by the formation of a large, firm thrombus containing the greater part of the dye-oil. The pulmonary vessels were sometimes quickly obstructed. When used in divided doses, small ones of .2 to .5 Cc., there was often no apparent difference in action from that produced by the pure oil.

In using the dye-oil, the main object was to see if it would be taken up by the cells from the emboli in the capillaries; that is, an attempt was made to ascertain whether the fat in the cells giving the appearances of fatty degeneration derived these large fat-granules from its own invisible fat (true degeneration) or whether it was in reality an infiltration of fat into a dying cell. In the living tissues the dye-oil loses somewhat of its color, but never all in the time consumed by these experiments. The fat-droplets in the degenerating cells are, however, most of them paler than the emboli outside in the capillaries, and the cell-protoplasm tends to take on a diffuse red color. The majority of fat-droplets in the cells are perfectly colorless. This question has not been an easy one to decide; but my opinion is that the majority of the fat-granules in the degenerating cells are derived from the emboli in the capillaries, and that the process is essentially an infiltration into, or, in other words, a taking-up by, the damaged cells of great numbers of fat-droplets. There must exist then a peculiar attraction between the fat and the dying cells. A smaller portion of the finely-divided fat-granules in the cells comes from the cell itself.

Experiments 19 to 24.—Dogs were used to determine the effects upon the heart and circulation of injections of oil into the heart directly, into the jugular vein, and into a heart compensating for an artificially-produced valvular lesion. Tracings were made of the carotid, right auricle, and the jugular. The injection of 7 Cc. of oil directly into the heart causes a rapid fall of carotid pressure, and an increase in that of the auricle and jugular, as shown in the charts. Repeated injections cause large systolic pulsations in the right auricle, the arterial pressure steadily falls, and that of the auricle and jugular goes steadily up. Finally there is delirium cordis and death. The action of the fat-embolism is in all ways the same as that of air-embolism. The heart is unable to propel it onward, and there is finally delirium and cardiac paralysis.

In the case of fat-embolism of the heart in a case of compensated artificial lesion, as a tricuspid insufficiency, the injection of the oil causes a rapid break in the compensation, manifested by a great fall in the carotid pressure and a rise in auricular and jugular pressure. This is very well shown in the tracing made by Dr. Rous in the class of experimental pathology when he was teaching that course in my department some four years ago.

Experiments 25 and 26.—It was thought that a dye-oil made of the fat of the given animal might be more easily taken up by the cells of an animal of that species than a foreign oil. Scharlach R. chicken oil was accordingly used in experiments upon chickens. In these experiments it was found that minimum doses of the dye-fat caused almost immediate death. Smaller doses caused well-marked symptoms. Frozen sections showed pulmonary vessels injected with the red oil, marked pulmonary stasis, hemorrhage, and thrombosis. No appearances of fatty degeneration were found in the muscles, so that the point as to the taking up of the fat could not be definitely decided.

ETIOLOGY OF FATTY EMBOLISM

From the literature we find that the entrance of fluid fat in large or small amounts into the blood stream and its lodgment in the capillaries of the lungs or systemic circulation are of frequent occurrence, and may be caused by the following:

1. All varieties of injuries to bones affecting the marrow, particularly fractures. The degree of injury may be marked or apparently slight. Comminuted fractures are the most dangerous. (See general bibliography.)

2. Surgical operations, such as amputations, brisement forcé, rédressement, reduction of dislocations, resection, orthopædic manipulations, pressure upon atrophic spongiosa, use of chisel, concussion, etc. (See special bibliography.)

3. Concussion without fractures. (Ribbert, Flournoy, Gröndahl.)

4. Acute periostitis and osteomyelitis. (Flournoy, Jolly, Klebs, Wagner, Niederstadt, Gröndahl, Field.)

5. Hemorrhages into bone-marrow.

6. Presence of foreign body in marrow. (Riedel, Déjerine.)

7. Crushing, inflammation, or necrosis of adipose tissue in any part of the body (mastitis, removal of breast, ovariotomy). This leads to fatty embolism more rarely than does injury to the bone-marrow. (Ferguson, Riedel, Praeger, Pinner, Warnstedt, Fitz, Flournoy, Jolly, Bürger, Gröndahl.)

8. Rupture of fatty liver. (Hamilton, Zenker, Gröndahl, Engel.)

9. Childbirth. (Warthin.)

10. Lipæmia due to disease, as in diabetes, pancreatitis, gout, certain forms of anæmia, chronic nephritis, chronic alcoholism, acute fevers, chronic tuberculosis, splenitis, menstrual suppression, chronic diseases of liver, pancreas, and heart, general carcinomatosis or sarcomatosis, etc. In these forms of lipæmia the amount of fat in the blood is usually small, and the embolism is confined to the lungs and unimportant. (Sanders and Hamilton, Starr, Ebstein, Saundby and Barling, Fischer, Gröndahl, Degenhart, Rauch, Martens, Jürgens, Fraenkel, etc.)

11. Lipæmia due to intoxications, particularly with hæmolytic substances such as potassium chlorate, also with phosphorus, carbon monoxide, acute alcoholism, etc. Chloroform narcosis appears to

favor the development of fatty embolism. (Puppe, Romanow, Winogradow, Carrara, Bürger, Gröndahl.)

12. Fatty degeneration of thrombi, intima of blood-vessels (arteriosclerosis and atheroma) or heart, or of various cells gaining entrance to blood streams, etc. (Müller, Cohn, Lancereaux, Waldeyer, Egli.)

13. In cases of tetanus, eclampsia, delirium tremens, strychnine poisoning, and other convulsive affections. (Virchow, Gröndahl.)

14. In burns of the skin affecting the panniculus. (Carrara, Pacinotti, Gröndahl, Foa.)

15. Portogenous fatty embolism of liver. (Rössle, Gröndahl, Wiessel, Berner.)

Fatty embolism of clinical importance is in the great majority of cases due to injuries of the bones containing fatty marrow; less frequently it is caused by injuries to adipose tissue. Other forms of lipæmia and fatty embolism are of pathologic interest only, as the fat is of small amount, and the embolism usually limited to the pulmonary capillaries, causing no symptoms. Only in extremely rare cases does a fatty embolism of importance arise from any source other than the bones. It follows then that the greater the amount of fatty marrow in the bone the greater the chance for a serious lipæmia and resulting embolism; hence *osteoporotic* bones in old people or in younger individuals who possess *atrophic* bones from non-use (orthopædic conditions) are especially likely to yield on injury a sufficient amount of fat to cause trouble. Males are more frequently affected than females; adults than children. Repeated injury or concussion favors the entrance of fat into the blood stream. Fractures of the tibia and femur are the most frequent causes of fatty embolism. When many bones are broken, or there has been a severe concussion of the entire body, the fat may pass into the blood stream within a few seconds, and the symptoms develop almost immediately. In other cases the transportation of the fat may take place slowly and extend over a considerable period. In the case of osteoporotic bones direct pressure upon the ends may be sufficient to propel the fat into the blood stream. The amount of fat required to produce a fatal embolism is usually estimated at 1 Cc. per 1–2000 Gm. body weight. According to Scriba, 210 Gm. are necessary to cause fatal fatty embolism in man, but in a case reported by Fibiger 50 Cc. produced

fatal cerebral embolism. Chloroform narcosis, tight bandages, massage, movements, jarring, etc., are regarded as favoring factors. Payr's theory that cases of lymphatic struma are especially liable to fatal fatty embolism has no foundation beyond that of coincidence in certain cases. As orthopædic manipulations are usually made upon children, and as lymphatic struma is frequently associated with orthopædic conditions (rhachitis), such coincidence might be expected to be frequent. The association of fatty embolism with death during chloroform narcosis may be explained in the same way as a result of the coincidence of the lymphatic constitution and orthopædic manipulation requiring chloroform, with death due to the lymphatism rather than to the fatty embolism. This would explain the very sudden deaths which occur during narcosis.

In general it may be said that our knowledge concerning the etiology of fatty embolism is more complete than that concerning its pathology, symptomatology, and treatment. The majority of the German writings upon the subject have been especially concerned with the etiology, and all of the earlier experimental work was carried out from this standpoint alone. Not until Scriba's paper appeared did the general pathology and symptomatology receive proportionate consideration; and in Gröndahl's recent monograph the other aspects of fatty embolism are for the first time adequately discussed.

PATHOLOGY OF FATTY EMBOLISM

From the study of the literature, the examination of my own cases, and experimental work with animals, the following statements concerning the pathology of fat-embolism can be made with some confidence that they express the true nature of the condition.

1. General Pathology.—*Entrance of the Fat into the Circulation.*—At the site of the bone injury there is often found a mixture of liquid fat and blood, or fat and pus. Fat-droplets may be detected in the discharges from the wound or from the incisions. In the case of osteoporotic bones cystoid cavities filled with liquid fat are found. From the broken fat-cells and fat-spaces the fat enters the open veins of the bone, the tension at the site of the injury usually being greater than that in the veins, so that the fat is readily forced into or taken up into the venous circulation. This may occur immediately

after the injury, or the taking up of fat may proceed for some time, so long as there is free fat at the seat of injury or until coagulation takes place. In addition to the fat taken up by the blood-vessels there is also an entrance of fat into the lymphatics, this occurring later than the direct entrance of fat into the circulation. The fat-droplets pass the regional lymph-nodes and enter the thoracic duct, thence pass through the venous circulation into the lungs. This passage of fat through the thoracic duct occurs usually some time after embolism of the pulmonary vessels from the fat gaining direct access to the veins. Hence an exacerbation of the symptoms is noted when this second supply of fat reaches the lungs, and, if the patient survives the first embolism, he may succumb to the second blocking up of the pulmonary and cerebral vessels. As the fat passes into the arterial system it may be forced through the systemic capillaries back into the veins and produce a definite cycle of symptoms.

2. The *tissue lesions* in fatty embolism and the consequent symptoms depend wholly upon the amount and distribution of the fat which has gained entrance to the circulation. It is evident that the latter factor is the more important. Three times as much fat might be poured into the blood stream of one individual with less effect than if one-third as much were injected into the circulation of another person. The result depends largely upon the destination of the emboli. It is, of course, evident that the larger the amount of fat in the blood the more likely are important regions to be overwhelmed by the fat. Evidently both individual and local factors serve to determine the course of the fat and its effects upon the organism.

Certainly the body, even the brain, can stand a relatively large amount of fat in its capillaries before the final limit of obstruction is reached and damage to the tissues ensues. In all cases of fatty embolism of the lungs some fat reaches the kidneys and is excreted. It must also reach the brain and, temporarily at least, lodge in some of its capillaries. But miliary hemorrhagic infarctions of the brain occur only when there is a marked degree of obstruction, stasis, and secondary thrombosis. The same thing is true of all the other organs of the body.

There is not a single organ or tissue in the body—be it thyroid, pancreas, adrenal, testis or skeletal muscle—that does not get some fat in its capillaries during a fatty embolism. (Figs. 1–15.) Ana-

tomical considerations and the peculiar organization of tissues will determine the result. As the fat enters the venous circulation first, the heart and the lungs first bear the brunt of it. When the fat suddenly enters the blood stream in large amounts, the effect upon the heart may be the same as in air-embolism. The cardiac contractions are insufficient to drive the fat on into the lungs, and it remains in the right ventricle, increasing perhaps in amount, and exciting the formation of fibrin. The heart may gradually be exhausted, delirium may ensue, and sudden death. It is extremely likely that many of the cases of death within twenty-four hours after an injury are the result of cardiac paralysis.

The heart is further impeded in its action by emboli within its own vessels. A vicious circle may thus be set up, and the organ become more and more embarrassed. With the formation of fat-emboli in the coronaries local infarctions of the heart muscle are likely to occur, and these serve to bring about the final break in cardiac efficiency. In such cases there is a great fall in arterial pressure, and a corresponding rise in the venous; the heart-rate is very rapid and irregular. It is, therefore, proper to speak of a *cardiac symptom-complex* in fatty embolism. The importance of this has been strangely overlooked before. The autopsy findings of cardiac conditions support the belief that it is not rare. Colley and a few other observers are the only ones who have regarded the part played by the heart as of any consequence.

In all cases the pulmonary capillaries get the greater share of the fat-emboli, but the lung is better able than any other organ to withstand this condition. Nevertheless, as not infrequently happens, the lung is overflooded, and so many of its passageways are blocked that a *respiratory symptom- and pathologic-complex arises*, as shown by cyanosis, dyspnœa, pulmonary œdema, hemorrhage, and hemorrhagic infarction. Beyond the lung, in the systemic circulation, any one organ may receive the greatest damage from the emboli. If it is the brain, then there occurs a *cerebral symptom- and pathologic-complex*, easily recognized clinically and at autopsy. Congestion, stasis, thrombosis, hemorrhage, hemorrhagic infarction, and areas of degeneration characterize the cerebral lesions. Headache, vomiting, restlessness, apathy, clouded sensorium, diminished reflexes, low or high temperature, delirium, paralysis, coma, convulsions, and death

result from these lesions. Yet, if not too severe, recovery may take place.

The blocking of the glomerular capillaries of the *kidney* does not produce any appreciable lesion in this organ. Slight hemorrhages, congestion, stasis, etc., are occasionally seen, but no marked degenerative lesion.

In the *adrenals* there may be extensive blocking, hemorrhagic infarction, and fatty degeneration. We cannot yet recognize clinically such an *adrenal symptom-complex,* and we do not know what part these lesions may play in the cardiac disturbance. The extreme fatty change in the *liver* may be in part a protective function.

Likewise in the *pancreas* the island of Langerhans may be blocked with fat-emboli, and the cells of the island be markedly infiltrated with fatty granules. What disturbances may be caused by this we do not yet know. The same thing is true of the *thyroid.* There is extensive blocking of the capillaries of this organ in fatty embolism, but we cannot recognize any effects, although some functional disturbance must occur.

Fatty change in the *diaphragm* may be associated with disturbances of circulation and respiration. In the *skeletal muscles* numerous areas of fatty degeneration and embolism may account for some of the general malaise and fever. In all of these minute damaged areas protein change must be going on, and various intoxications may be secondary to the embolism. Emboli occur also in the capillaries of the *stomach, intestine, bladder, lymph-nodes, thymus,* blood-spaces of the *spleen,* etc., without causing recognizable tissue-changes.

We recognize, therefore, at the present time only three chief *lesion-* and *symptom-*complexes in fatty embolism: *cardiac, pulmonary,* and *cerebral.*

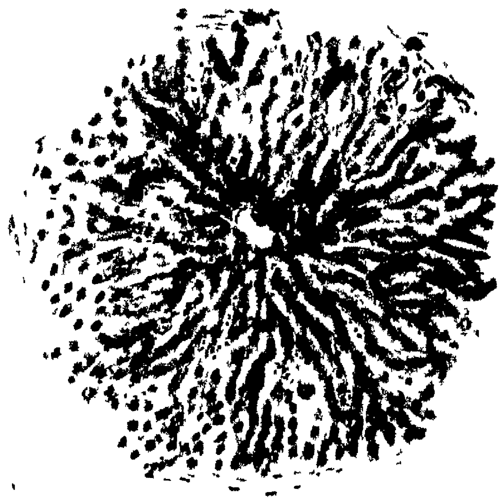
The action upon the blood must always be borne in mind. In some cases an active hæmolysis takes place, and a large amount of blood may be lost. Blood-pigment casts may be present in the urine.

3. The minute areas of tissue infarcted by the fatty emboli show in certain organs, such as the heart, skeletal muscles and diaphragm, liver, adrenals, pancreas, and spleen, an especial tendency on the part of the injured parenchymatous cells to take up fat-droplets. This tendency is not similarly shown by the thyroid, kidneys, brain, salivary glands, testis, etc. There must exist some especial attraction

FIG. 8

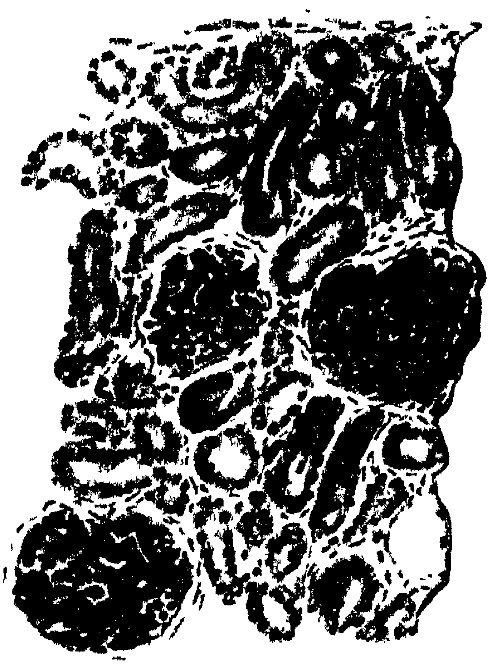
Infarcted area of heart-muscle showing fatty degeneration of muscle about fatty emboli, from case of fracture of tibia. Frozen section, stain Sudan III and hæmatoxylin

FIG 9



Section of liver from case of fatty embolism following fracture of both legs; death ten hours after injury Fatty emboli in central zone of lobule Surrounding liver-cells loaded with fat-droplets. Present appearances of fatty degeneration Sudan III and hæmatoxylin stain, frozen section

FIG 10.



Section of kidney from case of fatty embolism following fracture of tibia Free fat in urine Glomeruli filled with fatty emboli Free droplets in tubules Sudan III and hæmatoxylin stain of frozen section.

FIG 11.

Section of thyroid from case of fatty embolism dying ten hours after fracture of both legs. Thyroid was practically destitute of colloid. All capillaries filled with fatty emboli Sudan III and hæmatoxylin stain, formalin fixation, frozen section.

between the fat of the emboli and the injured protoplasm of these cells. In the case of the liver it is worth noting that this "fatty degeneration" or agonal fatty infiltration occurs chiefly about the emboli in the capillaries which flow into the central veins, but may also be found anywhere in the lobule and at the periphery.

4. The *excretion* of the fat is chiefly through the kidneys, in periodical cycles, in accordance with the movement of the fat from the arterial to the venous side and back again. The passage into the tubules is accomplished in the glomeruli, and not in the epithelial cells of the tubules. Phagocytes also convey the fat-droplets out of the body in great numbers, especially in the sputum, fæces, and bile. No doubt much of the fat is utilized by such organs as the liver.

5. SPECIAL PATHOLOGY.—*Lungs.*—The *macroscopic* changes characteristic of fatty embolism are: Œdema, congestion, hemorrhage, hemorrhagic infarctions, acute emphysema, and the presence of oil-droplets in the larger vessels. The *microscopic* changes are: Fatty emboli in larger and smaller vessels, as a rule evenly distributed throughout the lungs, the capillaries being dilated to two to six times their normal diameter, and the fat confluent in branching cylinders corresponding to the course of the capillaries. In the larger arterioles the fat-droplets often form spherical masses that are not confluent. Œdema, hemorrhage, congestion, hemorrhagic infarction, blood-plate and fibrin thrombi, bronchopneumonia, and emphysema are the chief secondary changes seen microscopically. Emboli of bone-marrow cells are also numerous. (Figs. 1 and 2.)

Heart.—*Macroscopically* the presence of fat in the subepicardial vessels may be recognized. Both ventricles, usually the right more markedly, are dilated, and miliary hemorrhages and patches of fatty degeneration are seen in the heart muscle. *Microscopic* examination shows the presence of fat-emboli in great numbers in the blood-vessels, and in the immediate neighborhood of these the heart muscle may reveal localized fatty degeneration of a peculiar kind (numerous large droplets), congestion, hemorrhage, thrombosis, and small anæmic infarcts. It would seem that some of the fat in the muscles is not the intrinsic fat of the cell thrown into view as a "fatty degeneration," but is taken up by the injured muscle-cell from the neighboring fat-emboli. (Figs. 6, 7, and 8.)

Brain.—*Macroscopically* the brain shows scattered miliary hemor-

rhages ("cerebral purpura" of Schmidt), most abundant in the white matter and near the ventricles, and often found in groups. *Microscopically* the small hemorrhages are found arranged around vessels filled with fat; these are surrounded by a small area of necrotic or degenerating brain tissue, outside of which is an encircling zone of red cells, giving the hemorrhage a wreath shape. The majority of these hemorrhages are the size of a pin-head, although some are larger. They are minute anæmic infarcts within a hemorrhagic zone. Fibrin thrombi are also found in some of the vessels, usually in association with the fat-emboli. According to the literature (Gröndahl, Ribbert, etc.), these hemorrhages do not appear until two or three days after the injury. I have found them abundantly in a patient dying twelve hours after fracture of the bones of the leg. (Figs. 3, 4, and 5.)

Cord.—The *macroscopic* and *microscopic* appearances of the cord are similar to those of the brain, but the lesions are fewer and less marked.

Kidneys.—*Macroscopically* the kidney usually shows only congestion. *Microscopically* the fat-emboli are found particularly in the capillaries of the glomeruli; a much smaller amount of fat being present in the intertubular vessels. Congestion and small hemorrhages are usually present, but degenerative changes are not the rule. Very rarely are fat-droplets found in the tubules. (Fig. 10.)

Skin.—Miliary hemorrhages in the skin sometimes occur in severe fatty embolism. These hemorrhages take place about vessels filled with fat, and the obstructed blood-vessel shows fatty degeneration of its wall.

Striated Muscles.—These show changes similar to those in the heart muscle: Fat-emboli, miliary hemorrhages, and localized marked fatty degeneration about the vessels containing emboli. In the case of the voluntary muscles, the taking up of fat from the emboli is even more decided than in the case of the heart muscle. (Fig. 14.)

Liver.—*Macroscopic* appearances are those of passive congestion. *Microscopically:* Fat-emboli in the capillaries, and localized fatty degeneration or infiltration. (Fig. 9.)

Spleen.—*Macroscopically:* Congestion. *Microscopically:* Congestion and numerous fatty emboli without other recognizable changes.

FIG 12

Section of adrenal showing multiple areas of hemorrhagic infarction and fatty degeneration due to fatty embolism From case of fracture of both legs. Death ten hours after injury. Sudan III and hæmatoxylin stain of frozen section.

FIG. 13

Alevolar cells loaded with fat-droplets. From sputum of case of fatty embolism showing marked pulmonary œdema. Fracture of femur. Death three days after injury Sudan III.

Pancreas.—Numerous emboli in capillaries of the island of Langerhans, without other recognizable charge. (Fig. 15.)

Adrenals.—No *macroscopic* changes. *Microscopically:* Numerous fat-emboli in capillaries of cortex, with localized fatty change in parenchymatous cells. (Fig. 12.)

Thyroid.—Numerous fatty emboli. Deficiency of colloid. No other recognizable change. (Fig. 11.)

In all other organs and tissues more or less numerous fatty emboli without recognizable change.

PATHOLOGIC TECHNIC

For the recognition of fatty embolism the fresh material should be cut on the freezing microtome, stained with Sudan III, Scharlach R., or osmic acid, and mounted in glycerine-gelatin; or formol may be used as a fixing agent. After formol fixation the material may be cut on a freezing microtome and then stained with the various fat-dyes mentioned. Flemming's solution or one per cent. osmic acid may be used to fix tissue containing fat-emboli; the osmic acid acts only upon the oleates. When fat-containing tissues are imbedded in celloidin or paraffin, the process of imbedding should be carried out as quickly as possible; chloroform or benzene should be used in place of xylol.

1. STAINING OF FAT WITH OSMIC ACID

1. Fix in formol twenty-four hours.
2. Wash; freeze; cut.
3. Place sections in one per cent. osmic or Flemming's solution one to twenty-four hours.
4. Wash in water, changing frequently.
5. Eighty per cent. alcohol one-half to two hours.
6. Wash in water.
7. Place section flat on slide; blot; add a drop of warmed glycerine-gelatin; cover quickly.

To mount in balsam: After 6, counterstain with hæmatoxylin or safranin; wash again; dehydrate quickly with absolute alcohol; clear in pure benzene; mount in pure melted Canada balsam (containing no xylol).

2. STAINING WITH SUDAN III OR SCHARLACH R.

1. Formol fixation twenty-four hours; cut on freezing microtome.

2. Sections in seventy per cent. alcohol.

3. Stain in acetone or alkaline alcoholic solution of Sudan III or Scharlach R. for two or three minutes; in the simple solution twenty to thirty minutes.

4. Wash in fifty to seventy per cent. alcohol, differentiating as needed.

5. Transfer to water; thence to slide; blot; and mount in glycerine-gelatin.

For a nuclear counterstain put the sections in water after 4; then stain in hæmatoxylin; differentiate quickly in acid alcohol; wash in water; place in weak ammonia or lithium-carbonate solution; wash in water; transfer to slide; blot; mount in glycerine-gelatin.

Staining solutions of Sudan III or Scharlach R. are made as follows:

1. Dissolve stain in seventy to eighty per cent. boiling alcohol; keep in the incubator over night; use warm.

2. Make a solution of absolute alcohol 70 Cc., ten per cent. caustic soda solution 20 Cc., water 100 Cc. Saturate with stain, warming gently.

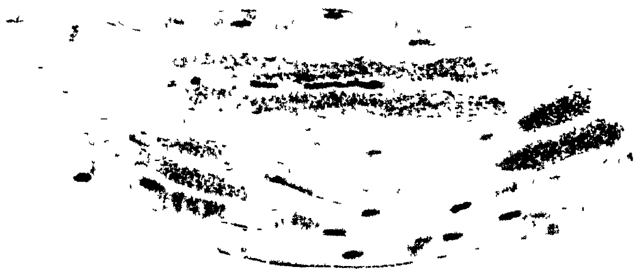
3. Make a solution of seventy per cent. alcohol 50 Cc., pure acetone 50 Cc.; saturate with stain.

Sudan III and Scharlach R. stain the smallest particles of fat yellowish-red to deep scarlet. Scharlach R. on the whole gives the best results, and especially good pictures are obtained when contrasted with hæmatoxylin.

SYMPTOMATOLOGY

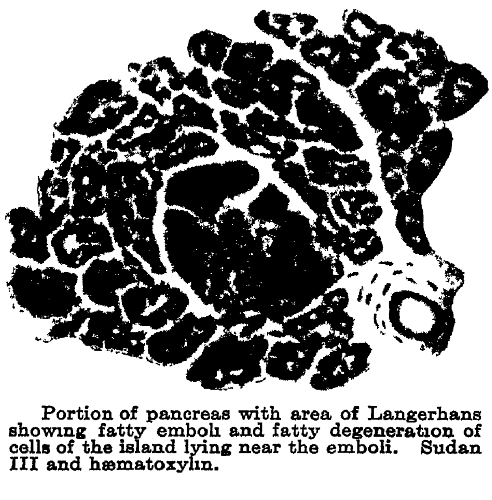
The symptoms of fatty embolism vary greatly, accordingly as the brain, lungs, or heart receives the greatest number of emboli, and shows a corresponding disturbance of circulation. The earlier observers concerned themselves with fatty embolism of the lungs alone, and failed to examine the brain, or to consider the possibility of a fatal cerebral fatty embolism. Not until Scriba's paper appeared was the importance of fatty embolism of the brain recognized. His dictum that the fatal outcome of any case of fatty embolism is always

FIG 14.



Portion of muscle of leg showing fatty emboli and fatty degeneration of the muscle-fibres about the emboli. Sudan III and hæmatoxylin.

FIG 15



Portion of pancreas with area of Langerhans showing fatty emboli and fatty degeneration of cells of the island lying near the emboli. Sudan III and hæmatoxylin.

due to a plugging of the cerebral vessels was generally accepted for a time, and led to more careful examination of all the organs and tissues after death from fatty embolism. As a result of the more recent studies Scriba's view has been proven to be incorrect; and, while the great importance of cerebral fatty embolism is recognized, two clinical types of fatty embolism are distinguished: A *pulmonary* and a *cerebral*. It is also possible that in some cases a *cardiac* type may be differentiated.

Pulmonary Fatty Embolism.—In its symptoms and course this is clinically less characteristic than the cerebral, and its diagnosis correspondingly more difficult. The chief symptoms are respiratory: Dyspnœa, cough, cyanosis, pulmonary œdema, and hemorrhage. These symptoms may develop immediately after the bone injury (apoplectiform cases), or their development may be slow. The respiratory symptoms may or may not predominate. In many cases it is impossible to make a diagnosis until an autopsy is performed. Death may taken place almost immediately, or the patient may live for several weeks. There may be an initial free interval before the respiratory symptoms appear. Restlessness, headache, and stupor may be the first symptoms; or a respiratory difficulty may suddenly develop, and the patient suffer from most severe air-hunger. The heart-rate is increased, the rhythm irregular, and the tension low. Precordial or epigastric pain may be felt. The right heart, especially, is dilated. The temperature may be low or high; more frequently it is low at first and rises gradually after a few hours. The respiratory rhythm may be irregular; the resonance is slightly diminished, and becomes somewhat tympanitic in character. Moist râles are heard over the base, and there is marked pulmonary œdema, the sputum often running from the mouth in a foamy mass. Often it is blood-stained, and free fat can be demonstrated in it by staining with Scharlach R. Fat appears also in the urine.

In fatal cases asphyxia may rapidly develop, following closely upon the trauma, and the patient dies in apparent collapse. Between the fatal and the non-fatal cases there is no sharp line; nor is there such between the respiratory and cerebral forms. The first form usually comes on soon after the trauma, but may be delayed, while the cerebral variety develops later, although it also may appear within a few hours. In the respiratory form cerebral symptoms may

develop as the result of anæmia of the brain and carbonic acid increase in the blood.

The *cerebral* form usually manifests itself after an intervening period, often three to eight days, but may come on within a few hours. In these cases the pulmonary lesion is less prominent than the blocking of the cerebral vessels. The patient's first symptoms are uneasiness or headache, drowsiness, mental cloudiness, stupor; sometimes there is vomiting, often hallucinations or delirium passing into a somnolent or comatose state. The skin is pale and may show petechiæ, and the lips are bluish. Reflex excitability is gradually lost, and there may be definite spasms, tremors, convulsions, or paralysis (even hemiplegia). While signs of cortical irritation are usually present, those of increased intracerebral pressure, such as choked disk, slow pulse, and rigidity of neck, are invariably absent. The respirations are greatly increased, and cyanosis and dyspnœa may be marked. Symptoms of the respiratory form are usually added to those of the cerebral. The Cheyne-Stokes phenomenon is often present. The pulse becomes very rapid, weak, and irregular. At the beginning the temperature may fall, and may remain subnormal to the end; more frequently there is a rising temperature curve reaching to 104° to 105° before death, and sometimes persisting at this height for several hours postmortem. In many cases the symptoms show three distinct stages: A free interval, a soporific stage, and a comatose. In the cases that recover there may be only the first two stages.

In both forms free fat may appear in the urine, but is most abundant in the cerebral form, giving evidence of the flooding of the arterial system with fat. It appears periodically, as described above. It may form an actual layer on the surface of the urine, or a small number of fat-droplets alone may be seen floating on the surface. Associated with the fat there may be red blood-cells, casts of different types, particularly blood-casts containing fat-droplets. Albumin may or may not be present. If there is pulmonary œdema, fat-droplets will be found in the sputum. The blood also should be examined for fat-droplets.

It is evident that in all cases in which there is fat in the urine some fat must also reach the brain, and the occurrence of cerebral symptoms depends upon the amount of fat reaching that organ. It

is highly probable that in all cases of fatty embolism some fat must get into the cerebral circulation. If the amount is small, and if the capillaries are blocked for so short a distance that no serious disturbance of the nutrition of that part is produced, it is unlikely that there will be any serious cerebral symptoms, or at most only transitory ones. The normal lung can bear a great deal of fatty embolism without damage; and the same is true in a lesser degree of the brain.

DIAGNOSIS

Fatty embolism may be mistaken for shock, collapse, *commotio cerebri, contusio cerebri, compressio cerebri,* hysteria, intracranial hemorrhage or inflammation, acute or chronic alcoholism, delirium tremens, sunstroke or heat-exhaustion, diabetic or uræmic coma, septicopyæmia, etc. At times the diagnosis may be easy; at other times it is extremely difficult to differentiate between fatty embolism and some of these conditions, notably intracranial hemorrhages. When the patient has received injuries about the head the difficulty of differentiation becomes greater. Consideration of the temperature, heart's action, pulse, respiratory, and cerebral symptoms is of little avail, as practically all the clinical phenomena characterize these various conditions in common, and it becomes impossible to separate them. The occurrence of a free interval in many of the cases of fatty embolism will distinguish them from shock, *commotio cerebri* and *contusio cerebri.* In the case of meningeal hemorrhages and *compressio cerebri* the differential diagnosis is at times very difficult. In fatty embolism the cerebral symptoms are more diffuse, the centres are not affected regularly, or as a part of a definite system. Choked disk and the other signs of increased intracranial pressure are not seen.

In general the diagnosis of fatty embolism should rest upon those considerations that are peculiar to it alone. In the first place, it should always be looked for after any damage to bones containing fatty marrow, no matter how mild this injury or concussion may appear to be, also after orthopædic manipulations of atrophic bones. If after such operations or injuries symptoms of restlessness, sleepiness, and coma develop, with dyspnœa, cough, and signs of pulmonary œdema, then the diagnosis of fatty embolism is very probable and

the objective signs of this condition—*fat in the urine* and *fat in the sputum*—should be positively determined. The presence of fat in the blood may also be ascertained by examination of the retinal vessels, or by removal of a large amount of venous blood.

Fat in Urine.—Riedel and Scriba were the first to show that fat-droplets appear in the urine after the majority of bone injuries. Other writers have reported negative findings. It must be borne in mind that lipuria is often delayed for several hours or days, and that the patient may die before it occurs; also that lipuria is usually intermittent. There may be a layer of fat on the surface of the urine, or only large fat-drops.

New Diagnostic Sign.—The presence in the sputum of free fat-droplets and of numerous phagocytes containing an abundance of fat-granules is here put forth as a new and extremely valuable diagnostic aid. In 1906 I began to teach my classes that fat in the sputum is an important and early sign of fatty embolism of the lungs, basing my belief upon a case I had seen in which an old man, after a fracture of the femur, showed sputum containing blood and large numbers of fat-droplets. Carrington (1908), quoted by Le Conte and Stewart, is the only other writer who, so far as I have been able to discover, mentions this sign. He is quoted as having found it in six cases. Gröndahl does not mention it. I have confirmed this finding in all cases of fatty embolism which I have recently seen, hence regard it as a most valuable sign. Fat escapes by rupture from the dilated capillaries of the lungs before it passes from the kidneys. If the pulmonary obstruction is at all marked the amount of sputum will be increased, and in this sputum will be free fat-droplets and alveolar cells containing large fat-droplets. Stain the fresh unfixed sputum under a cover-glass with Sudan III. Occasionally cells containing fine fat-granules are found in ordinary sputum; after pneumonia they are more numerous, and small fat-droplets may then be found free. They are never as large or numerous as in fatty embolism.

The differential diagnosis of fatty embolism chiefly depends, therefore, upon the following factors:

1. Injury to bone-marrow or adipose tissue.

2. A cardiac, pulmonary, or cerebral complex of these combined (restlessness, stupor, coma, dyspnœa, cough).

3. Free fat-droplets in sputum: Fat-containing alveolar cells in sputum.
4. Free fat-droplets in urine.
5. Examination of eye-grounds for evidences of fat in circulating blood.
6. Examination of venous blood for fat-droplets.
7. Increase of temperature, rather than a lowered temperature as reported by Scriba, and as quoted in the text-books.
8. Examination of skin for petechial hemorrhages.

COURSE

The course of fatty embolism may be rapid or slow. The cases are described as *apoplectiform,* with fatal result at once or within a few hours; or the symptoms and signs may persist for several days or weeks, then to terminate fatally or in recovery. In apoplectiform cases the diagnosis may be possible only through the autopsy, as there may be no time for the development of a clinical picture presenting characteristic symptoms.

PROGNOSIS

The prognosis in well-developed cases of fatty embolism with recognizable signs and symptoms is grave. The majority die; the number of reported recoveries is small. It is probable, however, that the literature concerning this condition cannot be taken as a criterion of its prognosis. The cases that recover are probably not recognized as fatty embolism, but pass under the diagnoses of shock, collapse, concussion, etc. It is my own belief that a larger proportion of cases of fatty embolism do recover. A more careful observation of patients suffering from fractured bones will, I am sure, support this view.

TREATMENT

The treatment of fatty embolism is both *prophylactic* and *therapeutic.* The *preventive* treatment in the case of fractured bones is absolute rest and the avoidance of all unnecessary moving of the patient. Particularly is transportation over rough roads, or in a jolting vehicle, or even transportation for a long distance under any conditions, contra-indicated, because of the fatal outcome apparently

induced by such motion, as reported in the literature. Massage and tight bandages are also dangerous, as they increase the tension at the site of the injury and promote the propulsion of fat into the veins and lymphatics. In the case of orthopædic operations, particularly when there is disuse atrophy and osteoporosis of the bones, direct force upon the atrophic spongiosa, either by the use of the chisel to the bones or by direct pressure upon them, should be avoided. In all operations upon osteoporotic bones the saw should be used rather than the chisel, and concussion should be guarded against. The slow removal of the Esmarch bandage is also recommended by von Aberle, Gröndahl, and others. Especial care should be taken in orthopædic manipulations upon children of lymphatic constitution.

Reiner advises the puncture of the femoral vein, or the insertion of a cannula through the saphenous into the femoral, after bloodless orthopædic operations, so that when the Esmarch bandage is slowly removed the wave of blood flowing into the veins will wash out any fat that may be in the vessels. Lexer was unable to demonstrate the presence of fat in blood obtained in this way from the saphenous vein. Other writers are not enthusiastic over the method.

Lexer states that the most effective prophylactic against the occurrence of fatty embolism in orthopædic operations is to avoid the use of the chisel upon the spongiosa, and that a saw should always be employed in such operations as the bone may be sawn through without crushing or concussion. Further, he issues a warning concerning the employment of pressure upon the articular ends of bones in operations upon crooked limbs, particularly when the ends are atrophic and softened.

Ligation of the veins above the injury or seat of operation in such conditions as thrombophlebitis is also recommended for the prevention of infected emboli. By some surgical writers this is not considered a practical measure. In comminuted fractures free incision and drainage of the fat at the seat of injury, also incision and removal of stitches to relieve the tension, are recommended as preventive measures.

Therapeutic Measures.—After fatty embolism has occurred the treatment consists of measures to get rid of the fat in the blood stream by proper stimulants. Among the methods advised for the

removal or neutralization of the fat in the blood stream are the following:

1. Injections of two per cent. sodium carbonate solution. Czerny's experiments with this method were fruitless in so far as saving the life of the animal was concerned, although the dyspnœa seemed temporarily lessened. In one human case in which I saw this treatment given there was great lessening of the air-hunger, but the patient died. Minnich regards it as useless. It needs, however, a more thorough trial than has yet been given it.

2. Czerny recommended venesection to lessen the venous congestion, and also advised the injection of sodium carbonate solution after the bleeding. Temporary benefit at least may be obtained in this way.

3. Injections of physiologic salt solution into the veins are recommended by Schanz (1910). Eight out of ten cases of fatty embolism following orthopædic manipulation were treated by Schanz with saline infusions, the solution being injected at several points in order to accomplish most effectually the desired dilatation and flushing of the veins. If the symptoms are severe the saline solution should be injected directly into the large veins. The earlier the infusion and the larger the amount of salt solution injected the better the result. Schanz's success with this method is very promising, and it should be given a thorough trial. At least, it is easily carried out and can do no great harm. Gröndahl doubts that Schanz's cases were really fat-embolism, but this doubt does not seem well grounded. Lesser made an experimental therapeutic study of the effects of the injections of salt solution directly into the right ventricle in air- and fat-embolism, and recommends saline injections as a therapeutic measure in man.

4. *Drainage of Thoracic Duct.*—In 1910 Wilms recommended the establishment of a thoracic duct fistula in the treatment of fatty embolism, on the ground that more fat is added to that in the blood by absorption through the lymphatics, the fat passing the lymph-nodes and reaching the thoracic duct, whence it passes into the venous circulation some time after the fat that gained immediate entrance into the veins. This accession of fat may be the final straw in bringing about the fatal termination, and if this increase of fat in the blood stream can be prevented the patient may survive.

Wilms performed this operation in one case of fatty embolism in a patient who fell from a window. Sixteen to twenty hours after the operation the patient became soporific, temperature rose to 39° C., respirations 40. Believing the entrance of the fat to be chiefly through the lymphatics, Wilms opened and drained the thoracic duct, large fat-droplets appearing in the lymph. The fistula closed on the ninth day, and the patient gradually recovered. Wilms's method was used experimentally by Fritzsche (1910), who found that drainage of the thoracic duct warded off danger if performed at the first sign of trouble. Gröndahl, however, found experimentally that ligation of the femoral vein and removal of the inguinal lymphatic tissues did not prevent the occurrence of fatty embolism. Nevertheless, he thinks the method advocated by Wilms and Fritzsche is theoretically the best one in all cases in which there is a free interval with symptoms of cerebral embolism developing. He would consider the symptoms of a beginning cerebral embolism as indications for the establishment of a thoracic duct fistula, and that the operation should be performed as quickly as possible. The risk of the operation itself is slight, and the consequences negligible. On the other hand, as so few cases of fatty embolism diagnosed *intra vitam* live, the risk of the operation is nothing compared to that of the fatty embolism itself. As Gröndahl says, this method of treatment is certainly theoretically a good one, and surgeons should be urged to carry it out whenever there are indications of cerebral fatty embolism.

The combination of venesection, saline injection, and thoracic duct fistula may then be advised as offering at the present time some hope in the treatment of fatty embolism. All other treatment must be directed toward the prevention of further entrance of fat into the blood stream, and the relief of the dyspnœa by lessening the work thrown upon the lungs and heart. Cardiac stimulants, the administration of oxygen, artificial respiration, etc., are chief among other measures to be tried.

MEDICOLEGAL SIGNIFICANCE

The medicolegal significance of fatty embolism has been discussed by Wintritz, Puppe, Westenhoeffer, Bürger, Gröndahl, and others. Many questions of great interest are involved. From the literature the following points may be accepted as authoritative:

1. Fatty embolism of lungs, brain, and kidneys is always an *intravital phenomenon.* It does not occur in the capillaries of these organs after death; although putrefactive gas-emphysema may cause the entrance of fat into the large vessels, it cannot propel it into the small vessels of these organs, nor can burning after death cause this.

2. Fatty embolism in the lungs, brain, or kidneys of a person whose body has been burned must be taken as evidence that there was previous to death some injury to fat-tissues or bone-marrow, or severe concussion of the bones.

3. Fatty embolism as a cause of death after trauma must be excluded by autopsy examination before a diagnosis of death from acute alcoholism, intracranial hemorrhage, meningitis, insanity, hysteria, shock, etc., can be given. Particularly when there is any suspicion of foul play should this condition be looked for and considered as a cause of death. In my Case XI above cited, a fatal case of fatty embolism in a man who was thought to have been pushed down stairs was diagnosed as "acute alcoholism" by the coroner, and no investigation was ever made.

4. Fatty embolism is of medicolegal importance, therefore, as a cause of death, also as an indication whether a burned body had been injured in any other way before the burning. The criminal and insurance aspects of the question are obvious.

CONCLUSION

Fatty embolism should be looked for after all bone injuries and after orthopædic manipulations. Mild cases are probably very common, and fatal cases are certainly much more numerous than is suspected. The general failure of text-books and practitioners to recognize the importance of this condition is sufficient reason for a complete presentation of its etiology, pathology, symptomatology, and treatment.

NOTE.—This monograph was prepared in book form in 1907. Having deferred its publication, it has now been condensed and brought up to date.

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INTERESTING SURGICAL CASES

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CASE 1.—Cavernous nævus of nose. R. W., male, white, aged 2½ years, presented in the Surgical Out-patient Department of the University Hospital, April 2, 1913, with a cavernous nævus the size of the tip of the little finger on the bridge of the nose (Fig. 1) and two others on the back.

At the request of my colleague, Dr. R. H. Ivy, I undertook treatment with carbon dioxide snow. A pencil was prepared in the usual manner by tying a chamois cloth over the outlet of a carbon dioxide gas container and permitting the gas to escape into a little space in the chamois, which forms the mould of which the pencil, formed by the rapid evaporation of the escaping gas, becomes the cast. At the first treatment this pencil was applied directly to the tumor for 40 seconds. During this time the skin becomes frozen, the blood is driven from the vessels, and the tumor shrinks until, when the pencil is removed, it disappears and only a little frozen pit remains. With thawing of the skin, however, the blood-vessels fill again and the tumor wells from the pit to its former size. In this case the pencil was applied to the edges first, and the centre was gradually approached in the succeeding applications. Care must be taken lest too much pressure be used and necrosis result. Ten applications were made, the first six at weekly intervals, 40 seconds each time, and the remaining four fortnightly, 60 seconds each time. Two applications sufficed for the nævi on the back. The second picture (Fig. 2), taken August 9th, shows the residue of a few dilated vessels.

As Nyström (*Hygeia,* 1912, lxxiv, No. 1) says, this method is harmless, simple, painless, effective, inexpensive, allows exact dosage, and furnishes an ideal cosmetic result. It benefits protruding angiomata rapidly, but the flat and deep are influenced less, and do not always yield even to prolonged and intense applications. In the latter variety, as well as in angiomata involving the conjunctiva and mucous membrane, radium is the agent of choice.

CASE 2.—Erysipelas, chronic, face (St. Anthony's fire). J. M., aged 37, years, white, laborer, for 15 years has had three or four attacks of erysipelas a year, each attack lasting about three weeks. At the first visit, January 27, 1913,

FIG 1

Cavernous nævus on bridge of nose before treatment. (See Case I.)

FIG 2.

Nævus seen in Fig. 1 destroyed by ten applications of carbon dioxide snow. There is still some swelling, but most of the vessels are obliterated.

FIG 3

Round, indurated, localized, non-suppurating chancre of upper lip (See Case V)

FIG 4

Ulcerating gumma of neck, encircled by area of desquamating epithelium. Such an ulcer simulates the common tuberculous abscess. (See Case VII.)

that part of the face bounded by a circular line around the orbits and lower lip was red, congested, and swollen, especially the tip of the nose. A stock streptococcic bacterin, dose 400,000,000, was injected hypodermatically, and magnesium sulphate in concentrated solution ordered locally. On January 29th, two days later, he was greatly improved, the face clearing up with rapid subsidence of the swelling. He stated that this attack subsided more rapidly than former ones. Four injections were given at intervals of two and then three days. He did not report again until August 18, 1913, when he had a mild attack involving the nose and cheeks. He stated that since the bacterin treatment he had had no attack for a year. The same treatment was repeated, with the addition of sodium citrate, 20 grains hourly, to reduce the viscosity of the blood and to favor elimination of toxins by the kidneys.

Of 1084 cases of erysipelas treated by Pontano (*Policlinico,* 1912, xix, No. 1), 8.02 per cent. died, a mortality made up mostly of aged or much debilitated persons. In his hands serotherapy has given no conclusive benefit in the severe cases. He uses locally hot compresses dipped in physiologic salt solution and renewed every four hours. This malady must not be confused with erysipeloid, described by Rosenbach, which is due to infection of the fingers of cooks, butchers, and fish dealers from decomposing animal matter (Keen), as well as from crab bites (Gilchrist).

CASE 3.—Abscess of cheek. W. J., aged 25, male, colored, waiter, reported April 11, 1913, complaining of a lump on the right cheek of two weeks' duration. Inspection revealed an indurated ridge on the right side in the middle of the furrow between the nose and cheek. It was painless, and presented the signs neither of an abscess nor of a furuncle, nor of a dacryocystitis. Search for a primary focus was rewarded by finding carious roots which represented the remains of the discrowned first and second upper molar teeth. He was sent to the dental department, where these roots were extracted, in their wake pus welling forth, with rapid subsidence of the indurated ridge.

Curiously enough, the profession is just beginning to realize the importance of oral sepsis, with its sequelæ frequently so disastrous to the economy. Volumes are written upon the mysteries of gastrointestinal disorders, hidden in the dark recesses of the abdomen, but here at the very portal of the digestive tract, and playing the part of a watch-dog over it, is a set of organs that in health and in disease is proverbially neglected, and yet one whose secrets are at once revealed to the eye upon mere opening of the mouth! I maintain that the integrity of the teeth is of as much, if not of more, importance to the individual as that of the stomach, gall-bladder, pancreas. Locally,

lumps and sinuses about the face and cervical lymphadenitis, and, more widely, gastro-intestinal disturbances, sepsis, and metastatic infections, may be explained etiologically. In my clinic at the German Hospital I have been much impressed by the number of women whose suspected gall-stones, gastric ulcers, appendicitis, and pelvic maladies have been explained by either carious or missing teeth. The condition of the incisors and canines is no index to the condition of the premolars and molars. The former may be perfect and yet large gaps exist where the molars are missing, thereby abolishing the physiological function of grinding, and giving rise to mechanical indigestion, with its train of gastro-intestinal pain and discomfort, accumulations of gas, and constipation. "Biliousness" explains this syndrome in the minds of many. For further information, see article entitled "A Special Form of Dilatation and Displacement of the Stomach," by T. Sydney Short (*British Med. Jr.*, Jan. 18, 1908).

CASE 4.—Carbuncular furuncle of upper lip. H. Y., aged 38, male, white, carpenter, reported, August 16, 1913, that for six days he has had a painful induration of the left side of the upper lip, extending around the left nostril toward the inner canthus. This induration was decidedly inflammatory, and there was an œdema almost ligneous, between the angle of the mouth and the inner canthus. Diagnosis: carbuncular furuncle.

Under nitrous oxide anæsthesia an incision was made into the area of maximum bulging and the indurated tract curetted, flakes of lymph and much blood exuding. A rubber drainage tube was inserted and immediately flushed with Wright's sodium citrate-chloride solution to prevent a hæmatoma and to encourage bleeding. A drain-poultice of the same solution was applied and covered by wax-paper, cotton compress, and muslin bandage. The patient was given 30 grains of sodium citrate hourly to reduce the viscosity of the blood and to favor elimination of toxins by the kidneys. The next day the induration, to a large extent, had disappeared.

In this type of furuncle, which is larger than the ordinary boil, yet not so large as a carbuncle, nor with so many openings,—in fact, a furuncle with extensive perifurunculitis,—and especially when on the face and in the vicinity of the facial vein, incision and gentle curetting are strongly indicated. Ordinarily I do not believe in incising furuncles (*cf.* "Surgical Aspects of Furuncles and Carbuncles," *Penn. Med. Jour.*, 1913, xvi, No. 10, p. 790), but at this site there is great tension, and if the infection burrow to the deep fascia it is liable, though rarely, to enter and incite thrombophlebitis in the facial vein, and this may spread like wildfire along the ophthalmic

vein into the cavernous sinus, with eventual exitus. That is why we curette gently,—to draw the infection away from the vein and out into the surface dressing. Sometimes it is possible and advisable to ligate the facial vein above the area of infection. Boils here are always accompanied by a cellulitis extending toward the inner canthus, giving rise to the belief that phlebitis is already present. In most cases, however, the facial vein is not involved, but when it is, the local signs are much more exaggerated and the constitutional more severe.

CASE 5.—Chancre of upper lip (Chancre Labii Superioris). A. H., male, colored, aged 26, laborer, reported at the Polyclinic Hospital, service of Prof. Morris Booth Miller, April 1, 1913, presenting an ulcer upon the upper lip (Fig. 3). Two weeks previously he noticed a "pimple" the size of a pinhead, which gradually increased in size. It was painless and at no time discharged. He poulticed it with flaxseed. He also had submaxillary and submental (suprahyoid) lymphadenitis, which was *indolent,—i.e., painless.* This round, indurated, localized, non-suppurating ulcer in a negro presented the typical clinical picture of a true Hunterian chancre, and here opportunity arose for the ideal confirmatory diagnosis on the part of the laboratory,—the finding of *Spirochæta pallida.* Accordingly, lymph was expressed from the depths of the chancre, spread upon a glass slide, and examined upon a dark field. The spirochætes, with their regular short curves, were found. The patient was immediately dosed with mercury and neosalvarsan. Wassermann test at this time was negative, but two weeks later,—four weeks after exposure,—was positive.

Of the extragenital sites occupied by chancres, the lip is by far the most frequent (Bulkley). The primary lesion may involve either lip. The first Wassermann was not expected to be positive,—not until the chancre was from three to six weeks old. Therefore, *spirochætes should always be sought in an initial lesion.* After finding them the chancre should be excised, but here any advantage to be derived from such a procedure was more than offset by the mutilation that would ensue. Treatment should be immediately instituted before awaiting the appearance of secondaries,—provided, of course, the clinical diagnosis has been confirmed by laboratory methods. The earlier syphilis is attacked the less the hold it will get on the economy, and the attack must be powerful and energetic. To send the patient away with a bottle of the time-honored protiodide pills, and to administer neosalvarsan at spasmodic intervals, without Wassermann control, is *not* a powerful and energetic attack. The pills may be old, their complete absorption is conjectural, and the patient cannot be

relied upon to take them strictly according to directions. Too frequently repeated doses of neosalvarsan may damage the viscera. My method of treating syphilis is:

As soon as the diagnosis is confirmed by the laboratory, triweekly intragluteal injections of mercury are administered according to the following formula:[1]

			Gm. or Cc.
No. 1.	℞	Mercuric cyanide	1.0
		Novocaine	0.5
		Aq. dest. (sterile), q. s. ad	100.
	M. Label.		

Of this solution an initial dose of 10 drops is injected,—about one-twelfth of a grain of the mercury. The dose ascends two drops every other day until 15 injections have been given. The buttocks are used alternately. While this first course is in progress two intravenous injections of neosalvarsan, each ranging from Gm. 0.45 to 0.9, according to the individual, are given at fortnightly intervals. This course, therefore, is terminated at the end of a month. Now the following formula is prepared:

			Gm. or Cc.
No. 2.	℞	Mercuric cyanide	1.0
		Novocaine	0.25
		Aq. dest. (sterile), q. s. ad	50.
	M. Label.		

This merely doubles the strength of the mercury, and is made up solely to reduce the bulk the first course reaches by the end of a month (38 minims). Starting with 10 minims (1/6 grain), this is likewise increased two minims every other day until 15 doses have been given. Again, at the end of the month, 38 minims, representing two-thirds of a grain, are being taken. Neosalvarsan is again administered in fuller doses and at fortnightly intervals.

In these two courses, then, a total of 9 grains of the soluble cyanide of mercury, with 3.6 grammes of neosalvarsan, is taken within two months. This is a fairly rigorous course, for at its close the patient has had about as much mercury as he can stand. A treat-

[1] For these two formulæ I am indebted to Dr. George A. Wyeth, of New York City. I have modified them by substituting novocaine for cocaine, because the former is one-seventh as toxic as the latter.

ment-free interval of from four to six weeks is now allowed preparatory to a Wassermann test. Should the latter be made immediately its true value would be obscured by the mercury and arsenic still in the system. If weakly positive, the first course is repeated. If medium positive, both courses are repeated. There is no other way of attaining the goal of syphilotherapy—permanently negative Wassermann both in blood and in cerebrospinal fluid. On the other hand, if the test is negative, active treatment is suspended and the test repeated in six weeks, then at intervals of three months. In the course of the first year after infection the cerebrospinal fluid is withdrawn and subjected to a complement-fixation, a cytological and Nonne's Phase I globulin test at least once, to detect the possible onset of cerebrospinal involvement. If at the end of a three-year period of medical surveillance the Wassermann tests of both fluids continue negative, the patient may be considered cured and allowed to marry.

The great advantages of intragluteal therapy are accuracy of dosage and direct personal supervision of the patient by the physician, both of which factors promote his weal. The advantage of using the cyanide of mercury is that, being a soluble salt, it gets into the system, does its work and gets out, so that its toxic effects are but fugacious. For example, if gingivitis arise, it is but transitory. Mercurial colic and diarrhœa are readily controlled by bismuth subcarbonate in 15-grain doses, repeated p. r. n. Such rigorous doses of mercury are apt to cause loss of appetite and of a few pounds in weight. To combat this, after the mercurial course is over, it is astonishing to see a patient pick up by hypodermatic injections of that excellent alterative, sodium cacodylate (sodium dimethyl-arsenate), in 3-grain doses every other day. This is also an antisyphilitic, but there is doubt in the minds of many whether it inhibits the Wassermann reaction.

As to neosalvarsan (914), the consensus of opinion is that, with proper technic, it is a safe drug to administer in office work, although this question, too, has its *antis*. The intravenous method is superior to both the intragluteal and the rectal, for it is instantly carried by the blood-stream to the most remote corners of the body, there to exert its indirect complement-fixation reaction upon the spirochætes. Some consider it less efficient than salvarsan (606). That now and then a patient will be met with who exhibits an idiosyncrasy toward this

drug is unquestionable. I have seen one instance of this. To detect it, it is well to make the first dose small, especially if the body-weight is low. The contra-indications of renal inefficiency, Addison's disease, status lymphaticus, advanced cancer, chronic alcoholism and nicotine poisoning must be respected. A convenient method that I have employed successfully is to dissolve the neosalvarsan in 10 Cc. of tepid sterile physiological saline, fill a syringe of this capacity, and inject the solution directly into the vein of the recumbent patient, but he should not arise and leave the office immediately.

That combined treatment with mercury and neosalvarsan is best, is shown by the striking statistics presented by Gibbard and Harrison from the Military Venereal Hospital, Rochester Row, before the Seventeenth International Medical Congress at London in August, 1913. They stated that when mercury alone was used there were 83 per cent. of clinical relapses, but that since the introduction of salvarsan only 5.1 per cent. had recurred. Professors Ehrlich and Neisser both state that recurrences are the result of insufficient dosage with salvarsan, as well as of too short treatment, "spasmodic" administrations being worse than useless. On the other hand, it is possible to administer too much of the drug, so that a middle course must be pursued.

CASE 6.—Epithelioma of lower lip (Epithelioma Labii Inferioris). M. S., aged 52, male, white, insurance collector, was brought to me by Dr. C. M. Ewing, of Philadelphia, presenting a superficial ulcer, 1.8 cm. in diameter (the size of a dime), in the centre of the lower lip, with its anterior border at the mucocutaneous junction. Duration, four years. Surface of ulcer dry, not bleeding readily. In depth it extended to, but did not involve, the orbicularis oris. Submental lymph-nodes not palpable. Submaxillary enlarged on both sides to size of pea, but this was readily accounted for by the carious and tartared teeth, with their marginal gingivitis. It was planned to excise a piece for histological examination, and, since the ulcer was so superficial and indolent, to desiccate the remainder, with the high-frequency current. The patient was nervous and desirous of avoiding pain, and requested that no needle be inserted near the ulcer. Accordingly, it was decided to infiltrate the mental nerve and, as the ulcer occupied the centre of the border of the lip, it was patent that both sides must be anæsthetized. This plan was carried out according to the method I describe in *Surg., Gynec. and Obstet.* (now in press). Perfect anæsthesia in the distribution of both nerves was almost immediately obtained. A piece of ulcer was excised and the remainder desiccated with a long, deeply-penetrating, high-frequency spark without any pain whatsoever. A minute branch of the inferior coronary artery was cut, but the oozing was readily checked by pressure with cotton saturated with a strong solution of permanganate of potash mixed with adrenalin.

So perfect was the anæsthesia that I could readily have removed the ulcer radically and performed cheiloplasty, particularly since there was no patent metastatic carcinoma of the submental lymph-nodes to take me beyond the anæsthetic area. If necessary, the submental region could be anæsthetized by blocking the transverse superficial cervical nerve at the middle of the posterior border of the sterno-cleidomastoid.

Labial epitheliomatosis, like chancre, may involve either lip. Of 119 cases studied by Bloodgood (*Jour. A. M. A.*, 1910, lv, 1615), 13 involved the upper and 106 the lower lip, and of 80 examined by Borrmann (*Deutsch. Ztschr. f. Chir.*, 1905, lxxvi, 404), 6 affected the upper and 74 the lower lip. The precancerous possibilities of seborrhœa of the lower lip have been brought forth by Montgomery (*Jour. Cutan. Dis.*, Feb., 1913, 82), and Sutton (*Jour. A. M. A.*, 1913, lx, 1775) states: "If allowed to persist, a considerable proportion of seborrhœic keratoses undergo degenerative changes and ultimately become malignant, the resulting epitheliomas commonly being of an indolent, slow-growing type." It therefore behooves us to cure seborrhœic keratoses of the lips by the method employed by Sutton,—namely, preliminary X-ray exposures, followed by decornification with 5 per cent. salicylic acid ointment and thorough freezing of the base of the lesion (for at least one minute, under heavy pressure) with carbon dioxide snow.

CASE 7.—Gumma of neck. E. J., female, colored, aged 31, applied July 16, 1913, for treatment for swelling over upper part of right sternocleidomastoid of six months' duration. The apex of the swelling was ulcerating (Fig. 4). She stated that she had been treated at another hospital for five months and that the swelling had been lanced there, and had been discharging since. Upon searching for a primary focus a few carious teeth were found in the upper jaw and impacted cerumen in the right external auditory canal. But the lymph-nodes that drain those areas are not situated where this lesion was. The submaxillary take care of the teeth and receive the overflow of the pre-auricular lymph-node, which primarily intercepts the lymph-paths from the canal. There was no history of tuberculosis. A clinical diagnosis of gumma was made and blood taken for the Wassermann test. Three days later this was reported strongly positive (1 + units). Mixed treatment was instituted and neosalvarsan advised. The patient neglected the latter drug, but on August 4th, after 16 days of mixed treatment, the gumma had healed except for a small scab, under which was a drop of pus.

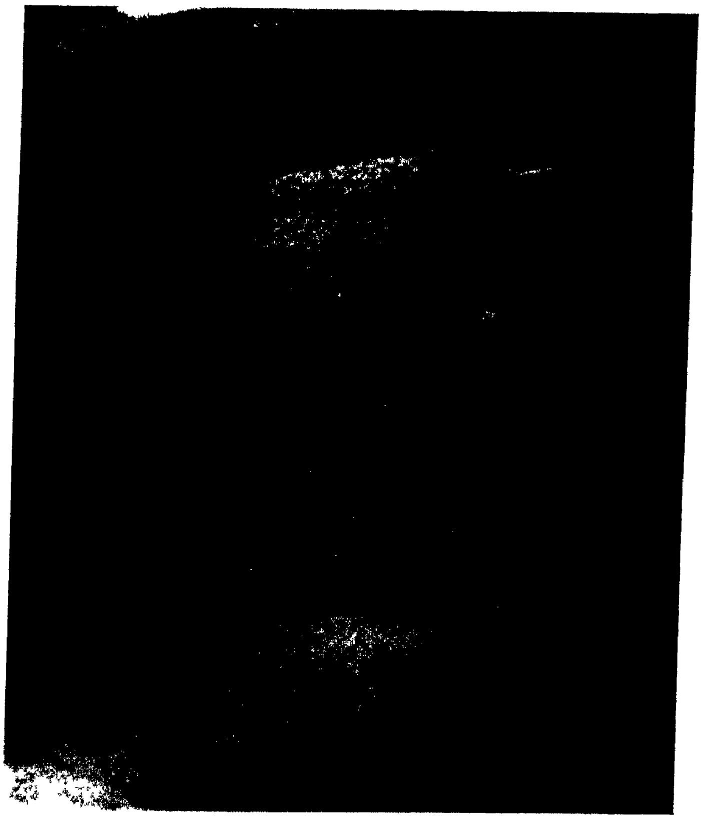
This lesion had evidently been mistaken for an ordinary cervical abscess, pyogenic in origin. That it did not heal within a few days

after incision should have aroused suspicion of a granulomatous formation. Being an isolated lesion, it could hardly be mistaken for tuberculosis, which usually involves a group of lymph-nodes, forming a conglomerate mass. I have no figures to quote, but I believe it will be found that some of the cervical sinuses of supposed tuberculous etiology will turn out syphilitic.

CASE 8.—Recurrent luxation of humerus. A. K., male, white, aged 60, clerk, presented at the Surgical Out-patient Department of the University Hospital, September 5, 1913, with the history of having fallen upon the left shoulder two days previously. He stated that the dislocated shoulder had been reduced in the receiving ward, and that since then a skiagram had been taken. Upon clinical examination I found the head of the humerus out of the glenoid cavity, and in the subcoracoid position. I then sent for the skiagram, which corroborated graphically the clinical findings. Nitrous oxide gas administered. With a bootless foot in the axilla as a fulcrum the humeral head was gently but rapidly replaced into the glenoid cavity. The patient was allowed to get up and walk over to th bench. When about to apply a dressing I found, to my astonishment, that th luxation had recurred, and immediately dragged the head back into place by pulling the upper part of the humerus outward and pushing the elbow inward, and maintained it in this position by applying a Velpeau bandage, with special reference to binding the elbow firmly to the side, and thus preventing recurrence. A second skiagram was obtained to prove reduction and to show cause of the recurrence. It proved the reduction, but showed no fracture. A third skiagram showed no fracture. The fourth skiagram, taken with the arm slightly abducted and rotated externally, revealed the separation of a fragment from the greater tuberosity, with upward displacement.

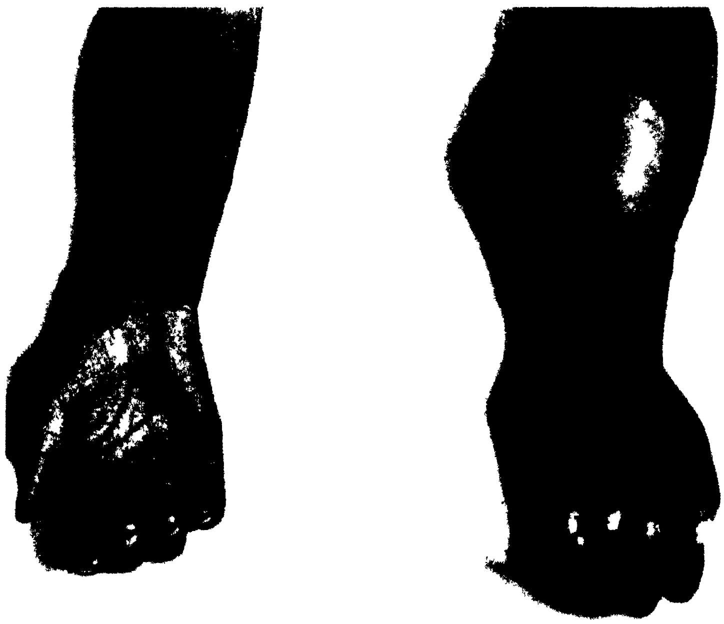
There are several interesting features about this case. In the first place, the facility with which it recurred indicated one of two complicating fractures,—tear-fracture of the greater tuberosity with retraction of the supra- and infraspinatus muscles, the more frequent, or separation of a portion of the inner margin of the glenoid rim. Which of the two existed, it was inadvisable to try to determine clinically. The strong suspicion of a fracture was not given up when the second and third skiagrams returned negative. The fourth skiagram was taken with the arm slightly abducted to reveal the condition of the glenoid rim, and slightly rotated externally to reveal the condition of the greater tuberosity; it showed fracture of the latter but not of the former. The separated fragment was drawn upward, as though from contraction of the supra- and infraspinatus muscles, thus abolishing their normal function of supporting the capsule. The first recurrence is explained by the application of an insecure retentive

Fig. 5.



Arteriectases of brachial artery in the lower third of the arm Upon compressing the artery proximally these little bulbs disappear. (See Case IX.)

FIG 6



Sarcoma of left forearm. Compare the ulnar border with that on the right side (See Case X.)

dressing, and the second by an incorrect and unsupported position during the walk from the table to the bench. I have no apology to make for having employed Sir Astley Cooper's method of reduction. I have used it before with success where Kocher's method failed in the hands of others. It is simple, rational, effectual, and in practice is remembered long after the steps of Kocher's have been forgotten. Gentleness is the watchword, lest the neurovascular bundle be lacerated or contused. The second time I employed Smith's method because it was the easiest and quickest under the circumstances. The Velpeau bandage was not removed until the end of the first week, when gentle massage was ordered. The arm was now placed in a sling, the massage repeated thrice weekly, and light passive movement added during the third week. The sling was discarded at the end of the fourth week, and active movements encouraged. No paralytic or other sequelæ ensued.

CASE 9.—Arteriectases of brachial artery. A. B., male, white, aged 57, janitor, reported June 10, 1913, with the history of the sudden appearance of two "lumps" in the right arm while painting a roof a week previously. Examination revealed two ectatic expansions of the coats (aneurisma verum) of the right brachial artery, the lower being 5 cm. above the base of the antecubital fossa and 2.5 cm. from the upper (Fig. 5). Upon compressing the artery proximally these little bulbs disappeared. Wassermann test negative.

We are here dealing with the incipient stage of a cylindric or of a fusiform aneurism. Each of the sites was a *locus minoris resistentiæ*, from atheromatous softening of the elastica, and it is not unlikely that when both yielded the forearm was flexed, thus retarding the current at the cubital flexure and increasing the pressure in the brachial artery,—a sort of indirect traumatism. The patient was sent to the Medical Department for cardiovascular examination and medication, and was advised to report to us again in the event of enlargement of the bulgings.

Illustrative of the rarity of aneurism of the brachial artery due to disease is the thorough search of the literature by Holt (*Amer. J. Med. Sci.*, 1882, n.s., lxxxiii, 382), who collected but 14 cases, including one of his own.

CASE 10.—Sarcoma of forearm (Sarcoma antebrachii). F. W., female, colored, aged 7, reported at the Surgical Out-patient Department of the University Hospital, August 19, 1913, presenting an enlargement of the left forearm of

four months' duration. History of sudden onset without trauma; no loss of flesh or impairment of health. Clinical examination shows a fusiform enlargement of left forearm, anterior aspect (Fig. 6), as though springing from the interosseous membrane and shaft of the radius, upper part. Tenderness and increased local heat over tumor. Epitrochlear lymph-node since three days much enlarged and hard; left axillary lymph-nodes palpable. Hand semiprone and cannot be supinated. Wassermann test negative. Skiagram showed no involvement of bones whose edges were clearly defined, and no ossification in the tumor. In excising a piece for histological examination the tumor was found beneath the muscles, was firm, grayish-yellow in color and fleshy, macroscopically resembling a sarcoma. Free bleeding followed removal of a small fragment. This was examined by Dr. John Speese, who furnished the following microscopic report: Specimen consists of fibrous tissue arranged in bundles which in many places are separated by masses of large, spindle-shaped, hyperchromatic cells with irregular distribution (Fig. 7). In the stroma numerous blood-vessels are found and a considerable quantity of extravasated blood. The number of vessels, however, is not strictly large enough to diagnose a vascular tumor in conjunction with the malignant one present. Amputation in the lower third of the arm was performed. I dissected the specimen and had it sketched (Fig. 8). The macroscopic description was communicated to the Pathological Society of Philadelphia, in whose *Transactions* for 1913 it will appear.

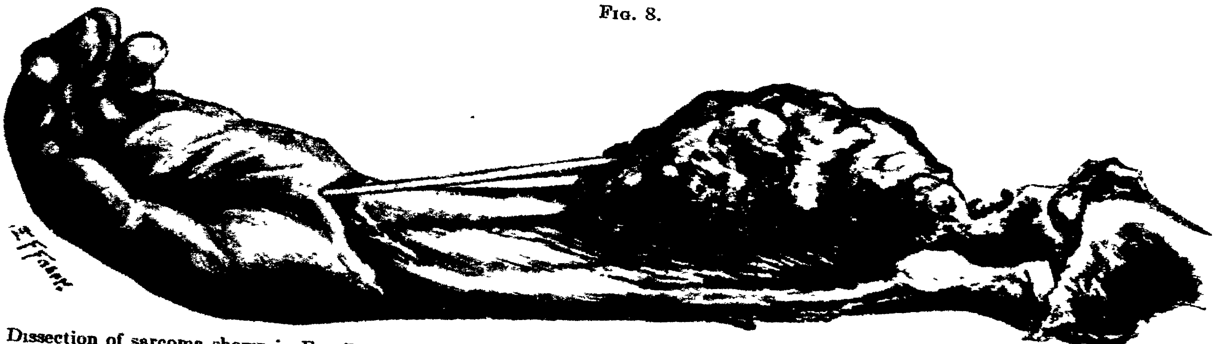
Sarcomata of the large spindle-cell variety, while not so malignant as those of the small round-cell or melanotic, are yet treacherous in their metastatic propensities, and are best treated by amputation. Giant-cell sarcomata, on the other hand, are the least malignant and therefore lend themselves to local removal, for, while they may recur and recur, yet widespread metastases are unusual. It may be noted that clinically there was increased local heat over the tumor, and that microscopically blood-vessels were found in such numbers as to suggest a vascular tumor. This is a good illustration of correlation between clinical and laboratory findings,—an interdependence that it is always good practice to follow out. This local heat might suggest infection, especially in the small round-cell variety, where, from being local, it often causes constitutional pyrexia. Murphy (*Surgical Clinics,* 1913, ii, No. 2, 333) says: "Small round-cell sarcoma . . . is associated with elevation of temperature and many times with general systemic intoxication, very closely resembling the clinical picture of an infection, and gives aneurismal pulsation."

CASE 11.—Fracture of radius and ulna; marked deformity; complete bloodless reduction. S. J., male, white, aged 16, reported April 21, 1913, with the statement that three days previously, while landing from a pole-vault, he fell upon the hyperflexed left hand, and that on arising there was much deformity, to reduce which three attempts had been made elsewhere. Examination of the skiagrams

FIG 7.

Microscopic section of the sarcoma pictured in Fig 8, removed for diagnostic purpose previous to amputation The specimen consists of fibrous tissue arranged in bundles which in many places are separated by masses of large, spindle-shaped, hyperchromatic cells with irregular distribution. (See Case X)

Fig. 8.



Dissection of sarcoma shown in Fig. 7 The tumor springs from the interosseous membrane and shaft of the radius (See Case X)

showed, in the anteroposterior view (Fig. 9), transverse dentate lines involving the radius and ulna 4 cm. above their lower epiphyseal lines, with displacement of lower ends of upper fragments inward ½ diameter, and, in the lateral view (Fig. 10), ventral displacement of lower end of upper fragment of radius one whole diameter, with but trifling displacement of the ulnar fragments. Under nitrous oxide gas anæsthesia, by manipulations consisting of counterextension followed by shifting of the upper end of the lower fragment of the radius inward and ventrally to meet the lower end of the upper fragment, the apposition shown in Figs. 11 and 12 was obtained. The forearm was splinted in full supination, to obviate the sagging of the bones toward the ulnar side, which occurs in the mid-prone position. After appropriate massage and passive motion thrice a week the posterior splint was removed on the 24th, and the anterior on the 28th day, when the patient was discharged and directed to favor the forearm and gradually resume its use.

To show that "a fairly large series of cases of fracture of the forearm, involving both bones *in some part of their* shafts, may be treated with satisfactory results without a single resort to operation," Ashhurst and John (*Amer. J. Med. Sci.*, 1912, cxliii, No. 6, 843) presented a study of 52 cases, stating that this is the type most often "and we believe usually quite unnecessarily" subjected to operation. If not reduced at the outset, the authors say that a little better position can be secured at each dressing until, by conservative means, the surgeon will secure quite as good as, and in many cases a much better result than, by operation, and in a shorter time. They give two indications for operation: (1) If the fracture cannot be properly reduced without operation, and (2) if proper reduction cannot be maintained without direct fixation of the fragments. Illustrative of the first indication is a case detailed by McGlannan (*Amer. Med.*, 1909, n.s., No. 4, 216), in which there was angular deformity and overriding following an ancient injury.

There is a tendency abroad to condone imperfect reduction with the plea that "a bad anatomical result does not always imply a bad functional result." Statistics are silent arbiters, and here they are. A bad anatomical result gives good functioning in only *29.7 per cent.* A good anatomical result gives good functioning in *90.7 per cent.* (Jones, *Liverpool Med. Chi. Jour.*, 1913, Jan. 1). Ashhurst and John state that in the middle of the shaft of a long bone it is sufficient to secure *firm bony union,* with *no appreciable shortening,* and with *preservation of the normal axis of the limb.* Here may be added the advice of Jones to *restore bones to their normal curve*

CASE 12.—Disjunction of lower epiphysis of radius. C. Z., male, white, aged 9, fell upon the outstretched right hand. Examination revealed annular tenderness 0.5 cm. above the radiocarpal joint, and a ridge projecting the same distance dorsally. Diagnosis made as in title. Skiagram (Fig. 13) shows the inferior radial epiphysis in relation by its palmar half with the dorsal half only of the metaphysis, it, with the hand, being displaced dorsally. The anteroposterior view, as usual in these cases, and as may be imagined by inspecting the lateral, would scarcely arouse suspicion of this injury, the modifying term "scarcely" being necessary because close examination of the plate indicates, though by a faint clue, the dorsally oblique slope of the carpal articular surface of the epiphysis, which is well shown in the lateral view. Without anæsthesia the displacement was reduced and treatment instituted as for Colles's fracture in a child.

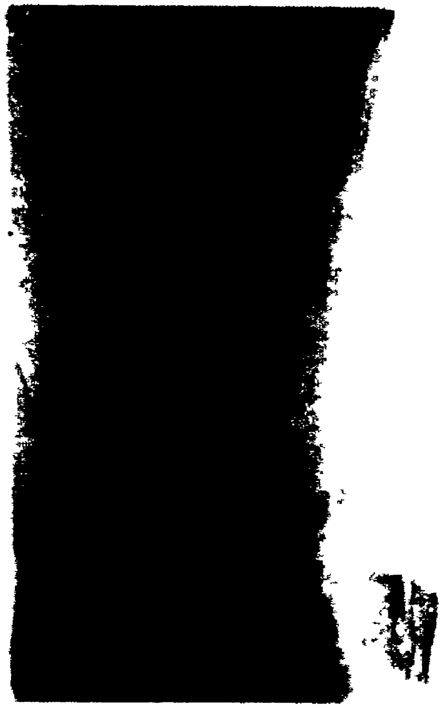
According to Ollier (*Internat. Encyclop. of Surg.*, 1886, vi), epiphyseal injuries include para-epiphyseal strains, in which the epiphysis is partially separted; para-epiphyseal sprains, in which the epiphysis is completely separated but not displaced; and disjuncted epiphysis with displacement, as in this case. Such injuries crop up about once a month, the alternative at this age being usually a subperiosteal "bending" fracture at Colles's site or a luxation of the elbow. They should be recognized and treated with care, both because of regard for the growth of the radius and because of consideration of the fact that here is an area of soft, newly-formed bone, freshly traumatized, a *locus minoris resistentiæ*, a tidbit tempting bacteria to pause in their journey along the blood-stream.

CASE 13.—Acute epiphysitis (metaphysitis) of lower epiphysis of radius. M. McC., female, white, aged four years, was brought by her mother to the Surgical Out-patient Department of the University Hospital, May 17, 1913, with the statement that 13 days previously the child had fallen on the porch upon its right wrist, whereupon the wrist began to swell and had continued swelling. Further questioning disclosed the facts that the child had always been delicate; that it had cough for a week; and that the previous summer it had had three subcutaneous abscesses, one on the right cheek over the parotid, one on the right thigh over the femoral lymph-nodes, and *one on the right arm just above the elbow (the worst)*: these appeared simultaneously and discharged "cheesy" matter throughout the summer. As regards herself, the mother stated that since six months she has been losing weight, and becomes fatigued easily: that she coughs, but the sputum is not blood-tinged, and there are no night-sweats; that her father died of "pneumonia" and a brother of pulmonary tuberculosis; that one of her children died 14 hours after birth, a "blue-baby," and that there had been one miscarriage. Locally, there was annular swelling *without redness* but with circular tenderness just above the right wrist-joint (the skiagram shows the swelling of the soft parts). Skiagram (Fig. 14) reveals osteoporosis of the lower metaphysis of the radius, the gnawed-at appearance showing in the lateral view as well (Fig. 15). The forearm was splinted and the little patient referred

FIG 9.

Fracture of radius and ulna Anteroposterior view before reduction Note transverse dentate lines of fracture, and displacement of lower ends of upper fragments inward ½ diameter (See Case XI)

FIG 10



Lateral view before reduction Note ventral displacement of lower end of upper fragment of radius one whole diameter, with trifling displacement of ulnar fragments. (See Case XI)

FIG 11

Complete reduction effected by manipulations as described in text. Anteroposterior view. Compare to Fig. 9 (See Case XI)

FIG 12

Lateral view after reduction Compare to Fig. 10. (See Case XI.)

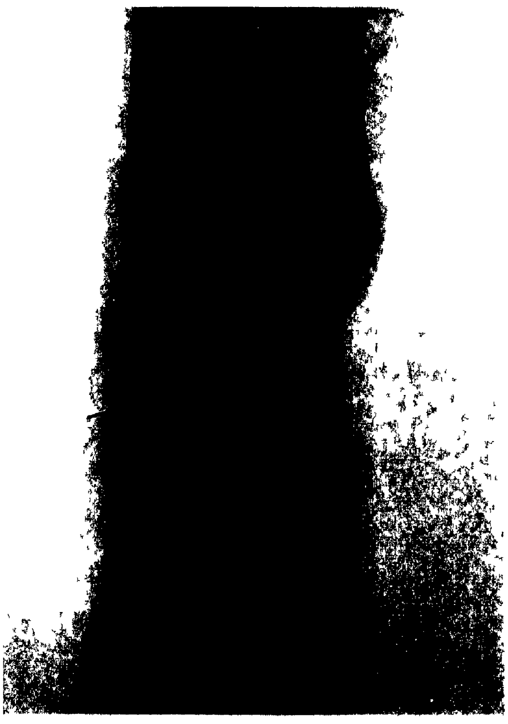
FIG 14

Acute epiphysitis (metaphysitis) of lower epiphysis of the radius Note gnawed-at area just above middle of epiphysis (See Case XIII.)

FIG 15

Lateral view of Fig. 14, showing osteoporosis of metaphysis.

FIG 13



Disjunction of the lower epiphysis of the radius Note degree of dorsal displacement: lateral view. (See Case XII.)

FIG. 17

Fungous type of tuberculous tenosynovitis. Opened to show oryzoid (rice) bodies, which are fibrin-derivatives. (See Case XIV.)

to Prof. J. P. Crozier Griffith's clinic for constitutional treatment. A note entered June 6th states that the swelling above the wrist-joint has increased, but there is still *no redness.* Shortly thereafter the child was taken to the Seashore Home at Atlantic City.

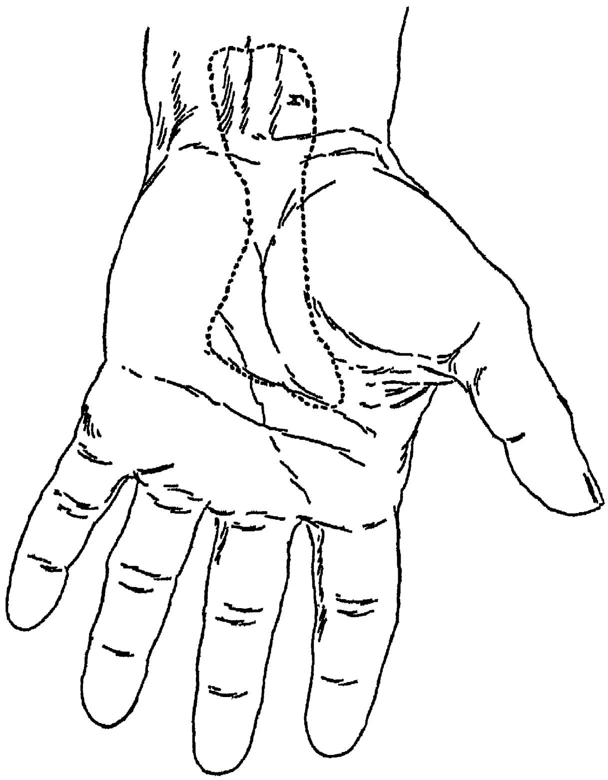
Perusal of the history furnishes the threads that weave the story of acute metaphysitis of the radius, of which para-epiphyseal strain (compare Case 12) was the forerunner. "The epiphysis being injured, there is a little effusion of blood, a little inflammatory reaction with stasis of the blood-stream, and any organisms circulating in the blood and reaching such a spot will have time to grow and multiply and set up an acute inflammation" (Kennedy, *British Med. Jour.*, July 29, 1912, 115). To this evolutionary phase might be added the anatomical fact that osseous proliferation and growth are more active on the metaphyseal side of the cartilage, whence exists a permanent physiologic congestion as the precursor of inflammation. The *degree* of pathologic mischief in this case may range from increased vascularity and thickening of the periosteum through suppurative osteoperiostitis (subperiosteal abscess) and osteomyelitis to, though rarely, osteoarthritis of the wrist-joint. The *location* of the initial lesion relative to the sectional area of the metaphysis,—that is, whether peripheral or central,—has been aptly compared by Barnard (*Lond. Hosp. Gaz.*, Feb., 1903) to the positions on a target. If in the position known as "an outer," the periosteum will be early and chiefly affected; if a "bull's-eye," the early spread will be down the Howship's vertical lacunæ, and the medulla will be early and chiefly affected; if a "magpie," the spread will be about equally distributed between medulla and periosteum (cited by Kennedy). As to the diagnosis, aside from the constitutional symptoms (delirium, rigors, etc.), which may be so severe as to warrant Chassaignac's appellation of "typhus of the limbs," local signs are of the utmost importance. Attention is directed to the metaphysis by the location of pain *near* a joint. In the absence of local œdema search for a *tender spot* in the metaphysis. Sometimes a little discolored patch, like a bruise, or occasionally like a patch of erythema nodosum, will point to this. Kennedy also states that radiography in most cases does not help, but that in mild cases, where the focus is early localized, a radiograph may show. We are fortunate in having an excellent skiagram, taken by

Dr. Pancoast. The family history, circumstances, and findings in this case lead me to suspect that we are dealing with that unusual form of osseous tuberculosis—the acute—which simulates an acute pyogenic infection, 77 per cent. of which are staphylococcal. This metaphysis is involved in 3.35 per cent. of metaphysitis in various localities. The only curb to immediate operation was the strong suspicion of its tuberculous nature, wherefore careful watching and constitutional upbuilding were considered best.

CASE 14.—Tenosynovitis of palmar bursa, tuberculous. C. B., female, aged 34, white, married, reported at the Surgical Out-patient Department of the University Hospital, May 19, 1913, having been referred by Dr. Sydney J. Repplier, of Philadelphia. She stated that two years previously (May, 1911), when grasping a scuttleful of coal, she experienced a "tear" in the palm of her right hand, but had no pain; had noticed no lump in palm previous to this incident. About two months later the little finger swelled, but this subsided in six weeks. During the same time the swelling appeared in the palm, and had remained the same size ever since. Clinical examination revealed distention of palmar bursa (flexor digitorum compartment), which was bounded, with fingers extended, below by upper transverse palmar crease; above by upper transverse carpal crease; on radial side by oblique thenar crease, and on ulnar side by hypothenar eminence (Fig. 16). On flexion of fingers this cyst ascends into the forearm 1 cm., and yields distinct succussive wave to finger-tips palpating above and below the anterior annular ligament. In December, 1912, after an attack of acute tonsillitis (of which there have been many since), cervical lymphadenitis appeared first in the right submaxillary region and then spread through the superior cervical lymph-nodes, anterior set. In August, 1912, involvement of lower anterior cervical lymph-nodes had appeared. Three weeks ago involvement of right axillary lymph-nodes appeared. These lumps are conglomerate, but not fluctuating. To ascertain the nature of this suspected tuberculous fluid, a spot of skin overlying the proximal end of the cyst was infiltrated intradermically with a solution of novocaine 2 per cent. with adrenalin 1 to 3000, and a trocar and cannula inserted into the upper extremity of the distended bursa. Withdrawal of the trocar was followed by the evacuation of 4 Cc. of turbid, viscid fluid containing flakes. Immediately after this the patient could flatten her hand out on the table for the first time. An alcohol dressing was applied and the hand splinted. Of this fluid, centrifugalized, I injected 1 Cc. into the traumatized left inguinal lymph-nodes of a normal guinea-pig, according to Bloch's method, and ten days later was rewarded by recovering typical acid-fast tubercle bacilli. The blood-picture of Hodgkin's disease was excluded by a normal complete white-cell count. On June 2d there was a reaccumulation of 3 Cc. of viscid, turbid, straw-colored fluid, which was removed and 1 Cc. of a 5 per cent. emulsion of iodoform in glycerine, freshly prepared, was injected. This was followed the next day by slight fever and burning pain in the palm, symptoms attributed not to infection but to absorption and irritation of the iodoform, which

was proved by their subsidence the next day. At this visit the patient thought the enlarged lymph-nodes were smaller. The palmar splint was reapplied. On June 16th there was a second reaccumulation of fluid: 2.5 Cc. were aspirated and a second dose of 1 Cc. of the same strength iodoform emulsion injected. Ten days later there was no reaccumulation; no fluctuation in bursa, only a slight thickening; no pain; axillary and cervical lymph-nodes subsiding; splint continued. On July 2d there was but a slight induration at the site of the bursa; board replaced. July 15th furnishes the same notes, to which the statement is added that heliotherapy was advised for the tuberculous lymphadenitis. On

FIG. 16.



Tuberculous tenosynovitis of palmar bursa Diagrammatic outline of distended bursa, the trocar puncture being made at *x*.

July 29th, ten weeks and a day since the first visit, the process in the palmar bursa was apparently healed, and flexion and extension were free. The enlarged lymph-nodes were still subsiding.

This is the "compound ganglion" of our forefathers, and of the exudative type (hydrops) because it appeared early. From the history it seems likely that the primary source of the tubercle bacilli was cryptogenetic through the tonsils, with metastatic hematogenous invasion of the palmar bursa, rendered a *locus minoris resistentiæ* by

the trauma of the coal-scuttle. It is also likely that the first and subsequent attacks of tonsillitis were abetted by the previous tuberculous invasion of the tonsils. These should have been removed. The pathology of this malady, according to Binnie (*Keen's Surgery*, 1907, ii, 451), is as follows: On section the sheath is found to consist of three layers. The outer layer is formed of fibrous tissue, more or less inflamed; the middle, of granulation tissue studded with tuberculous nodules (this layer is the active seat of the disease); the inner layer, of a deposit of fibrin varying in thickness. When the granulation tissue is present in great abundance, it may fill up and distend the tendon-sheath, causing a marked doughy swelling. This is the fungous type with its oryzoid (rice) bodies, as shown in the cut (Fig. 17), which was sketched from a specimen removed by Dr. Edward Martin, at the University Hospital, and kindly loaned to me by Dr. John Speese. These "rice bodies" are dead proliferations of partially developed tissue of fibrin of the small synovial villi or *Zotten* (Murphy, *Jour. A. M. A.*, 1912, lviii, 33, reprint). They, with the granulation tissue and fluid, contain small numbers of tubercle bacilli. The absence of pain in my case breaks no rule. The only inconvenience was that of interference with function. These two cases illustrate the extremes of treatment according to the extremes of pathology.

Case 15.—Warts of hand; multiple; desiccation. C. W., white, female, aged 21, mill hand, reported August 25, 1913, with the dorsum of the left hand peppered with warts (Fig. 18). Duration, one year. The dorsal branches of the radial and ulnar nerves were blocked with a few drops of a solution of novocaine 2 per cent. with adrenalin 1 to 3000. A few of the warts required, in addition, regional infiltration, because of not being reached by the nerves, for it must be remembered that the median sends filaments around the sides to the dorsum of certain of the phalanges. Desiccation with the high-frequency current, using a long spark, was applied to each wart. One application was sufficient, for within five days the warts could be picked off like berries from a bush. Ulcers remained which healed with boric acid ointment.

In International Clinics (1913, vol. iii, 23d series, 209) I illustrated two cases of warts, one of the thumb and one of the foot, and described the treatment in detail. This is shown as an example of an exceptionally widespread crop of warts, and emphasizes the unique efficiency of desiccation in their therapeusis. Too intense applications must not be made, else electric burns will result.

FIG 18.

Multiple warts of hand removed by desiccation (See Case XV.)

CASE 16.—Saturnine neuromyositis of adductor muscles of thumb. W. T., male, aged 19, white, painter, reported in the Surgical Out-patient Department of the University Hospital, August 2, 1913, complaining of weakness of left thumb, of pain in the left forearm and between the ribs. Examination revealed much phthisis of the muscular pad of the web of the left thumb. The anamnesis showed that a year previously he had begun his career as a painter's apprentice, and the *status præsens* had its incipience four months ago. His health had been failing during this time. His youth and brief career as a painter's apprentice established *prima facie* the diagnosis of *colica pictorum* of the neuromuscular form. He was referred to the Medical Dispensary for treatment. To exclude cervical rib as the etiological factor, I obtained a skiagram, which was negative.

This is an example of that most common and subtle form of poisoning: lead. Its detection in surgery is of the utmost importance, so that operation for lesions it mimics may be left undone. Just as this article went to press the author saw a patient who complained of "sciatic rheumatism," for which he had been treated elsewhere. There was "wincing" tenderness at the entrance of the left sciatic nerve into the buttock and a limp. Questioning revealed that he was employed in the "oil works," and further questioning showed that he had been soldering cans for four years, and that his trouble had begun three months previously with colic, constipation, and pains over body. Diagnosis, saturnism.

Lead enters the system in one of two ways: First, in the burning off old paint there is usually considerable stithe. Secondly, the use of sand-paper to make the surface flat creates a cloud of dust which is inhaled (Allbutt and Rolleston). Lead causes atrophy of peripheral nerves and of 90 per cent. of muscle-fibres, which, however, retain their cross striation. There may be chromatolysis of the anterior horn cells, the "*réaction à distance*" of Marinesco. There may also be granular changes in the red blood-cells. Lead may be recovered from the urine. This patient suffered from an acute form of plumbism which is preceded neither by colic nor by headache. The authors quoted refer to involvement of the thumb, stating that it may not be so easily extended, its abductor and adductor muscles being paralyzed.

After withdrawal of the patient from an atmosphere of lead, copious purging is good treatment. Potassium iodide is losing its advocates, for its powers of elimination are feeble, and it is apt to resolve lead that has been deposited in the tissues. This lad should be cured in several months.

CASE 17.—Weakness of both thumbs, occupational neurosis (copodyscinesia). Topographically of interest in connection with the preceding case is the following: L. G., male, aged 34, white, cigarmaker, consulted July 21, 1913, for "weakness" of both thumbs, when extremely flexed. Three years previously the right thumb had become involved, followed shortly by the left thumb. From being an expert operator the patient has become a mediocre one. Owing to similar symptoms having been reported in certain cases of cervical ribs, a skiagram was requested, but was negative. This patient exhibited psychasthenic stigmata. The diagnosis established, various and numerous methods were employed to help the patient, but failed.

Occupational neuroses are very difficult to deal with. The class of patients in which they occur cannot afford to lay up, and can seldom be persuaded to change occupation.

CASE 18.—Thecal abscess of finger. W. S., male, colored, aged 60, waiter, reported April 30, 1913, with a severe infection of the right index-finger; duration, one week. Clinical examination showed acute infectious thecitis of the flexor tendon sheath of the index, extending from the base of the ungual phalanx to the palmar ostium, and accompanied by a marked dorsal lymphangeitis, streptococcic in type. Under anæsthesia, vertical incisions were made over the middle of the anterior aspect of each phalanx, and through these openings creamy pus welled out. On the dorsum of the hand incisions two inches long were made over each interosseous space through the sodden skin and subcutaneous tissue, and from these thin lymph-plasma, characteristically streptococcic, exuded. The hand was immediately immersed into a vessel of hot Wright's solution. The dressing was composed of split rubber tubing, suitably placed; of gauze compresses soaked with hot Wright's solution, and covered with wax-paper, then a cotton compress, a retaining muslin bandage, a palmar splint, and finally a handkerchief sling, which was elevated until the hand rested upon the left shoulder. The patient was directed to take five drops of the tincture of the chloride of iron every hour, in water. Thereafter the swelling diminished gradually until, on May 7th, granulations were springing up. But it was noted that the ungual segment was undergoing mummification. He was now referred to the Medical Dispensary for investigation of the condition of the cardiovascular system. Dr. George Morris Piersol reported: "Chronic interstitial nephritis with arteriosclerosis (blood-pressure, 175 mm.; diastolic, 75 mm.) and myocarditis." He was directed to take Basham's mixture. By May 20th a well-defined line of demarcation had formed, and proximal to this an area of vigorous granulations had sprung up. Under local anæsthesia, amputation was performed at the base of the middle phalanx. On June 2d, the seventh week, a slough, representing the digital portion of the diseased flexor tendon, was removed. By June 11th the wound was granulating and epithelializing rapidly. On August 2d, ten weeks since the inception, the wounds were entirely healed, the patient had control of the stump and he was discharged, cured.

Digital abscesses are the price of negligent procrastination. That they jeopardize the patient's limb, his life even, is indubitable. The

human hand is the *ne plus ultra* of machinery, in the adaptableness and the intricacy of its mechanism; its muscles are more numerous than those of the prehensile organ of any primate; its blood-supply is prodigious, and its nerves are superlatively specialized,—a fact that is significantly driven home by the phrase: "To have eyes at the ends of one's fingers." There is barely the area of the point of a pin that has not its vater-pacinian body. Need it be wondered at that the shock of trauma, accidental or designed, flashes along the noci-association paths in the strongest, the fulminating signal for syncope? Or that the lattice-like system of thirsty absorbents, whose delicate tracery surpasses that of the finest seaweed, shortly deluges the economy with frequently overwhelming doses of bacterial toxins?

At times the question of the *depth* of the whitlow offers a perplexing problem. Apprehension of the fact that the tense distention of the tendon sheath with the products of pyogenic infection must needs interfere with flexion, is indicative, because based on that sound cardinal sign of acute inflammation, *functio læsa.* However, even the most astute of surgeons fails at times to gauge accurately the depth and extent of periphalangeal suppuration. The reason is plain. *He does not see what he is doing.* The blade of the knife is not sensed with vision, and *to thrust a blind knife blindly into the human hand is nothing if not criminal.* One who is deeply impressed with the marvellous construction and usefulness of the hand is inclined jealously to guard it from needless destruction. I have lately come to the conclusion that *every acute infection of the hand should be treated by an exploratory dissection under anæsthesia.* Here are the premises of the ratiocination:

1. There is a deeply-rooted instinct to withdraw the hand from harm's way.
2. The sight of the knife stirs up this instinct and predisposes to shock.
3. This instinct, together with the anticipation of pain, prevents coöperation between patient and surgeon, and thus militates against the best result.
4. The trauma of the incision precipitates the shock.
5. The shock may precipitate cardiac, neurasthenic, or other calamities.

6. To leave a pocket of pus unreached by drainage, even for a few hours, may cost the patient his limb, or a prolonged convalescence, or his life.
7. With anæsthesia the instinct, the mental impression from sight of the knife, the anticipation of pain, and the resistance of the patient are eliminated.
8. With anæsthesia the surgeon is enabled to explore calmly the infected area, and to determine its depth and ramifications, whereas without anæsthesia it is guesswork.
9. The risk of an anæsthetic is less than that of the factors given.

In view of the foregoing, *to operate without an anæsthetic is sheer brutality, surgical tironism, unjustifiable, and indefensible.* Even with an anæsthetic, nerve-blocking, with a view toward warding off the harmful noci-association impulses of shock, may well be considered.

Resuming the discussion of this case, it was mentioned that the dorsal lymphangeitis was suspected, clinically, to be streptococcic. This was proven by bacteriological examination of smears and of a culture of the pus. Pathognomonic of streptococcic infection are its roaming tendencies, contrasted with the localizing of staphylococcic, and the great degree of œdema and cellulitis. A culture taken two days after the incision was made revealed pyogenic staphylococci, which outnumbered the streptococci. It is very common for these to be mixed infections, the streptococci being the forerunners of the staphylococci. The incisions were made over the interosseous spaces because it is here that the larger lymph-vessels assemble to begin their centripetal journey. Incisions that reach these large vessels are of maximum efficiency because of the greater rapidity of depletion. The hot Wright's solution acts in several ways. By reason of the heat, it induces active arterial hyperæmia, thereby provoking more defensive agencies. The sodium citrate prevents clotting of blood and of serum, and so keeps the paths of drainage open. It may also be administered internally, in doses of 30 grains hourly, to reduce the viscosity of the blood and to favor elimination of toxins by stirring the kidneys to greater activity. The sodium chloride encourages osmosis of plasma, which flushes the depths of the infected area, and conveys

fresh phagocytes with their activating opsonins. In draining wounds, we do not employ gauze *corks*, which are so popular, on the premises that it is preferable to let the contracting walls of the abscess expel the pus through the lumen of a rubber tube rather than dam the pus by the desiccated or supersaturated end of the gauze. For a similar reason we deem it better to let Nature evacuate the contents of the abscess into the gauze dressings, even though more slowly, rather than traumatize the wound, spread the pus, provoke hemorrhage, and give pain by squeezing. A Bier cup does as much as squeezing is designed to do, but has none of its disadvantages. The wax-paper ensures the most favorable conditions under which wounds heal,—warmth and moisture. The cotton compress equalizes the circulation, allows for subsequent swelling, and prevents the bandage from being applied too tightly. A muslin bandage is specified because gauze bandages are so markedly inferior. They fray out, curl up, and loosen. In my experience, a muslin bandage that has been properly applied, and securely fastened by adhesive tapes or by pins, invariably remains in place. A sling is necessary, because elevation is one of the first principles of treating inflammation. The tincture of chloride of iron rapidly restores the appetite, when five drops are given hourly, and is less efficient when given according to routine in ten-drop doses three times a day. Because of the cardiovascular disease, a Wassermann test was made, but was negative. The gangrene may have been due to phenol dressings the patient used at home, and the arteriosclerosis may have played a part, as in the case reported by Hartung (*Berl. klin. Woch.*, January 27, 1913). In amputations of the fingers, if the base of the middle phalanx with the superficial flexor tendon is preserved, the stump can be readily controlled; otherwise, the proximal phalanx is of very slight utility. A slough that is permitted to stay in the wound retards healing.

CASE 19.—Frost-bite of fingers, first degree. The frontispiece depicts the frost-bitten fingers of a patient who had been exposed to intense cold while intoxicated. Pale patches of anæmia, due to spasm of the arterioles, are seen. As is usual in these cases, the effect of the cold gradually diminished from the little finger to the thumb, so that the middle, ring, and little fingers are most commonly involved. In the foot, also, the hallux appears to be less subject to frost-bite than the other toes. While the digits are freely supplied with blood, yet they are exposed to the cold from all sides, so that their heat is extracted more rapidly.

The diagnosis is easily made by the history, and by the current climatic conditions. Treatment should be carefully supervised, not only because of the economic value of the fingers, but with a view to preventing chilblains (pernio). Billroth (*Clinical Surgery*, 1881, 349) reports a case of frost-bite of the hands and of the feet that developed tetanus.

The time-honored treatment for frost-bite has been to raise the temperature slowly, lest moist gangrene result from the exudation that follows too sudden return of blood. Following Bier's teachings, however, Ritter and others have recommended superheated air, and they claim superior results (Freeman, in *Keen's Surgery*, 1907, i, 330). For this patient I employed Bier's hyperæmia, induced by applying a Martin rubber bandage just above the elbow on each side, and maintained an hour each day. His pain was relieved, and he seemed to improve more rapidly than other frost-bite cases. It appears rational, therapeutically, to endeavor to supplant the anæmic patches with hyperæmia.

GUNSHOT WOUNDS *

BY J. M. GASTON, A.M., M.D.
Of Laichowfu, Shantung, China

The following remarks are based upon personal experience during fifteen years' private practice in Atlanta, Ga., and four years' hospital practice in Laichowfu, Shantung Province, China.

The subject is presented in the hope of eliciting discussion which shall be of greater benefit than my brief presentation of cases. Of the cases treated in our hospital, the majority were wounded soldiers, and were, for the most part, natives of Shantung Province.

For convenience, I have grouped the cases according to anatomical location in the following order: Wounds of the head, throat and thorax, flesh wounds, wounds of the extremities, and abdominal wounds.

Wounds inflicted by the new rifles with Mauser bullets, as found in a few cases, were much more penetrating and less irritating than the rough lead bullets made by the native Chinese. The cases where the Mauser bullets passed entirely through the body, leaving a clean track, healed readily; but other cases where the old lead bullets struck a bone, even becoming imbedded in the bone, were frequent, and in some cases resulted fatally.

Wounds of the Head.—My experience with gunshot wounds of the head has been that the hemorrhage and tension of mechanical disturbance depend upon the location of the injury. Much depends upon the extraction of the bone; for fractured portions left do more harm than the presence of the bullet. The distinction between a compression from without and the pressure from within should be made.

I recall some cases treated in America. A boy of fourteen was accidentally shot by his brother, the bullet entering the temporal

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* Read before the Triennial Conference of China Medical Missionary Association, in Peking, January 15, 1913.

region and causing death within a few hours. The middle meningeal artery was ruptured, and the course of the bullet lay on the orbit. I had a specialist on eye and ear diseases in consultation, hoping to save the boy's life. The consultant passed a probe, which showed the brain to have been penetrated. Before we could operate, or stop the hemorrhage, the boy died. Another case was that of a white man, aged 55, who in a fit of despondency shot himself in the head. Here the temporal region was also involved, and caused such hemorrhage from the middle meningeal artery that packing with gauze was resorted to. Paraplegia from the pressure and clot was produced, and the man continued to live for several hours. When the packing was removed the clot was disengaged, and he regained the use of his limbs for a time before death. His case led me to investigate these injuries later, and to see how a New York surgeon, Dr. Blaisdell, was treating them. He removed large portions of the skull with a saw, and many recoveries resulted. He was very successful with these cases of open treatment of the brain.

In other portions of the body this course is also satisfactory. F. S. Dennis, of New York, has shown that a bullet may lodge in the brain and give rise to no disturbance of the nervous system. He speaks of bullets becoming encapsulated in the brain. He removed a bullet one week after accident which has the following history, given to the class at Bellevue Hospital, November 26, 1902. The patient, while sitting in a chair, was accidentally shot in the head by her husband with a .38-calibre bullet, which entered half an inch above the middle of the right eyebrow. At the moment of the report she experienced no unusual sensation, such as vertigo, or even much pain. She did not fall to the ground, was not unconscious, and was assisted to a bed, awaiting the ambulance. Her mind was perfectly clear, but there was profound hemorrhage from the nostrils. The bullet lodged in the niche upon the opposite side, behind and below the mastoid process. The main trouble in this case was from neuralgia of the fifth cranial nerve, the trigeminus, which was so distressing as to cause a serious complication. The only evidences of intracranial involvement were partial paralysis of the left motor fifth, with the paræsthesia in the sensory branch, and a partial paralysis of the left seventh nerve. These were peripheral or basilar, and not of cortical or central origin. The course of the

bullet was through the tip of the right frontal lobe and the left hemisphere of the brain.

No case of injury to the brain or large blood-vessel has come to my attention in China. It is presumed that such cases died on the field, as transportation facilities were poor. Two cases, in each of which one eye was destroyed by a bullet, were treated in our hospital. One was due to the accidental discharge of a gun in the hands of a soldier who was learning to shoot. The entrance of the bullet was in the temporal region near the superior orbital ridge, and the exit at the junction of the nasal bones with the orbital plate, so as to fracture them. Enucleation of the eyeball was done upon the morning after the patient entered the hospital. He had a good recovery. The second case was treated in my absence from Laichowfu. An attempt was made to save the eye without enucleation, and suppuration set up, evacuating contents of the eyeball. The best result to be hoped for in each of these was to save the uninjured eye from sympathetic ophthalmia. This was accomplished, and both men were satisfied.

Wounds of the Throat.—Wang T'swen Ch'en, aged 30, whom I saw in consultation with Dr. Hwang, of Tsinanfu. The patient was brought in by the Tsinanfu Red Cross corps from an engagement near Hwanghien. The bullet tract was through both œsophagus and trachea. No operation was undertaken other than swabbing and dressing. Food, when eaten, would come out through the opening in the gullet, while mucus passed from the trachea. The use of boric ointment and applications of mild antiseptics were made to the wound. He was given hypodermic injections of morphine. A cough mixture was also administered. The use of a stomach-tube for feeding with liquids was finally resorted to by Dr. Hwang. In writing of the case in a recent issue of the *Tsinanfu Medical Journal* (native edition) complete recovery is reported. In Atlanta I was called in consultation to see a girl of eight, accidentally shot in the throat. When I reached the patient she was almost asphyxiated by œdema of larynx and glottis. Examination showed a wound through the windpipe. I operated under chloroform. A tracheotomy below the wounded part and insertion of a silver tube with flanges and double tubing were successful. Daily removal of the inner tube for cleaning was done without inconvenience to the little

patient. Two months later the tube was removed and the wound closed. She had very good use of her voice.

Wounds of the Thorax.—Among the first wounded brought into our hospital by the Laichowfu Red Cross corps in January, 1912, were Kin Lan Seng and Chang Tei Chang. The first of these, aged 28, of Ch'ingchowfu, was found spitting blood caused by a wound of the thorax, the ball having passed out through the apex of the left lung. His temperature was 98 1/6 when first seen at Tru K'iao. He was given hypodermic injections of morphia sulphate, 1/4 grain, and atropine sulphate, 1/150 grain, with ergotin, at frequent intervals. He was removed to the hospital and kept under morphine until all symptoms disappeared. The wound was not probed. He recovered entirely. The second, aged 25, also wounded in the lung, received similar treatment at the same time and recovered. I saw him again in November; he told me he had no spitting of blood or cough, only itching at the former site of the wound of entrance, which had healed well.

An interesting case of a gunshot wound of the thorax involving the pleura and pericardium occurred in my practice in Atlanta. It was a result of the riot (sometimes known as the Atlanta Riot) of 1906, when several negroes were killed and wounded. William Deaver, a negro, aged 32, was seen October 6, 1907, for the first time. Operation—resection of rib and removal of bullet. Pus was found in the pleural cavity. This was evacuated and the wound treated as for empyema. His death occurred three days later. Autopsy was done and showed serous effusion in the pericardium with pericarditis. Pressure upon the heart was great. The case was of interest because the bullet must have passed so near the heart and remained in the body for nearly a year.

Flesh Wounds.—Flesh wounds of various kinds have been treated during the year. One little engagement at a point not far from Chefoo resulted in four wounded, who were brought to the hospital in shantzas, a distance of nearly 300 li (100 miles). These men had wounds of the legs and arms, partaking more of the nature of lacerated than of gunshot wounds. I suspect a shell had burst and wounded all four men. One had a large piece of shell embedded in the temporal region. This was easily removed with cocaine anæsthesia. The two of these patients who also lost their queues

seemed to regard it as insult added to injury. Other than flesh wounds would have fared badly under hardships of travel experienced by these men.

Ma Hi Wen, soldier, aged 24, wounded by bullet in left thigh, was also seen at Tru K'iao. The wound showed a clear track through the larger muscles. This healed well after he was removed to the hospital. Swen Hu Ch'en, aged 21, another clear wound produced by a bullet traversing the muscles of the shoulder. The wound, when seen, was gaping and undressed. He was given careful treatment with peroxide of hydrogen and a liniment of camphor, turpentine, and olive oil. His temperature was 101° when he entered. He recovered entirely, with slight disability of the shoulder and a long scar. This disability was due to the bullet's denuding the periosteum of the scapula. In the following cases the scapula was much more seriously injured.

Wounds with Complications.—Last Christmas morning a year ago a highway robbery occurred a few miles from Laichowfu. A merchant's courier, aged 35, was carrying silver from Chefoo to Tsinanfu. He was shot from the rear; the bullet, entering the spinal column and veering upward, shattered the spine of the scapula. There were other injuries from a knife, the eyeball and orbit being badly infected. The parotid gland was wounded and complicated his condition. The patient was brought to the hospital on the same day. The result of the operation done on this day was not satisfactory, although several pieces of bone were extracted. A second operation, when a counter-opening was made for drainage, gave relief. His symptoms did not indicate that the bullet had penetrated the pleural cavity, but that deflection of the bullet from the spine of the scapula had saved his life. He was treated two months, using permanganate of potassium and peroxide of hydrogen. The particles of bone removed at the first operation were followed by others which came out in dressing the patient. He left the hospital in fair condition, and reported later that the bullet came out. It is my opinion that the movement of the muscles during his first efforts to get off his clothing changed the location of the bullet and made my search ineffectual. It is known that bullets may come out at the same opening at which they entered, and it is possible that this occurred in his case. While I do not say that he did not tell me

the truth as to finding the bullet after he left, I doubted his statement.

Yu Chan Kwei, aged 40, entered our hospital with an old gunshot wound of the shoulder September 22, 1912. There were stiffening of shoulder joint and considerable deformity of the arm. The operation done was for removal of bony spiculæ and to close a fistula therefrom. Incidentally, search was made for the bullet, but was unavailing. The wound was treated antiseptically. Motion of the shoulder was partially regained, and the arm recovered its use. At first the wound had a bad odor and pus came, but by use of permanganate of potassium and peroxide of hydrogen this became less and less until the wound healed entirely. A counter-opening was made in this case, as in the case of the man reported as being robbed, only it was all done in one operation. He had the wound of entrance on the upper shoulder blade near the acromion process. The bullet was supposed to have gone down toward the spinal column. It is possible that the bullet is encapsulated in the thorax or near a vertebra, as there was a collection of pus near the seventh dorsal vertebra. However, he seemed satisfied with the result, which is better than might have been expected, considering the length of time which elapsed before surgical treatment. This recalls the case of a negro boy in Atlanta shot by a parlor rifle. An X-ray picture was taken at the time, showing the bullet near the right sixth dorsal vertebra. An operation failed to reach or remove the bullet, but the boy recovered, and another X-ray showed no change in the position of the bullet. It is a mistake to rely too much upon the X-ray in determining the location of bullets. The X-ray picture is only a shadowgraph, and must be corrected by a calculation of triangulation. In China I have not been able to avail myself of the X-ray. Doubtless some results would have been different, had it been possible to use this great aid to modern surgery. I have no doubt that many medical missionaries are without apparatus for X-ray work, hence I would emphasize the clinical importance of symptoms apparent after the inflammation has subsided. Some of the bullets I removed were in cases of fracture of the humerus, and I allowed the fracture to unite before attempting to remove the bullet.

In connection with cases just given may be added that of a man who had been shot in the back, the bullet entering at the twelfth

lumbar vertebra. Upon examination he was found to be suffering from complete paralysis below the waist line. He had retention of urine, requiring catheterization at regular intervals. The bowels moved, but the sphincter was also paralyzed. The tract of the bullet veered downward, and must have reached the spinal cord. He remained in the hospital a month, but at the end of this time was advised to go to his home, any operation being contraindicated. An interesting point in his casé was the fact that there was a subglenoid dislocation of the humerus, easily reduced under an anæsthetic. In this case I contemplated doing a laminectomy and searching for the bullet, but the risk seemed too great, owing to his depleted condition. Pus in the tract of the bullet was evacuated daily, and the wound dressed with permanganate of potassium and hydrogen peroxide.

Wounds of the Extremities.—The first case of a wounded soldier brought to the hospital was the case of a young man shot while trying to capture a robber. His arm was fractured by a bullet about the junction of the upper and middle third of the humerus. He had some hemorrhage, but we succeeded in ligating the bleeding vessels and used an internal angular splint, crutch-shaped at the axilla. This he wore for a month before I attempted to locate the bullet. When the bone was united the inflammation subsided, and the bullet could be felt and was removed through a counter-opening. He recovered entirely the use of his arm.

Hwang Lin Seng, wounded in the right arm near the insertion of the deltoid muscle. When first seen, January 26, 1912, he was on the road from Hwanghien, and was riding a donkey. His arm was hanging helplessly by his side, not even a sling supporting it. I had him brought into an inn, where he was put under ether and the bullet removed. The bullet was found to have struck the humerus and fractured it, lodging near the acromioclavicular articulation. The bullet itself was badly bent and was a Mauser, with a covering of brass. This man's temperature was 99.8° when I first saw him, January 26, 1912. His temperature rose to 101° on January 30, four days later. He was removed to our hospital and remained there until the humerus united. He was afterward treated for an abscess from necrosed bone. Later he was able to go back into the ranks. Tsei Lai Tei, aged 31, had a wound of the buttocks, the bullet penetrating the os innominata. He was put under an

anæsthetic and the tract was opened thoroughly. Only a portion of the jacket of the bullet was found. He was kept in the hospital some weeks until the tract had healed. He is now well and able to walk without assistance. Swen Yeo Siang had a bullet wound in the left inguinal region. The bullet was searched for under an anæsthetic March 18, but was not found. Disability of muscles. Second operation May 11: Cutting of muscles. Still, search was unsuccessful. November 6, third operation: Lengthening tendons at the knee; also found the bullet in a sinus left after the original wound had healed, and communicating with bone. The bullet was dislodged after having been in contact with bone, as shown by the white deposit on side of bullet. He left the hospital in December, walking well, with only a little support. The pain, rigidity of muscles, and other disability were overcome entirely.

Ie Sin King, a Manchu officer aged 21, was seen January 26. His temperature was 102.6°. He had a wound in the thigh, extending into the buttocks. Under ether, the tract of the bullet was found going into the os innominata. Chisel and mallet were used, but I was unable to extract the bullet. This operation was done in the inn. He was removed to the hospital, where he was given a separate room and attendants of his own, as well as hospital nursing. The bullet was not extracted until a month later. Lead poisoning supervened. Died three days after extraction of bullet. The symptoms of lead poisoning were such as blue line on the gums, general anæmia, and final stupor, with convulsive movements. These symptoms may have arisen from long confinement and infection of the system from the injured bone. The bullet was of the old kind, and made of lead of a nature easily absorbed. I found chisel marks on it from the first operation, but I was not aware at the time of this operation that I had reached it. His wound was kept open and dressed regularly, but at one time there was severe hemorrhage, which seemed to be from a clot that was disengaged. The place was inaccessible for ligation. At this time we used stypticin gauze, and hemorrhage was entirely stopped. I think that if the bullet had been left alone the results would have been better.

The fingers and hands have been wounded in a number of cases who entered our hospital, but only one in particular merits attention. Small shot such as used in shotguns often do more injury than

bullets or large shot. Su Yung Ch'ang, aged 25, entered the hospital May 5 and left June 8. Re-entered July 1. During the first interval he had twenty-two shot removed from his hand and fingers. Later, ten more were extracted. He took chloroform twice, and cocaine at times; at other times without any anæsthetic. I examined him November 30, and found no discharge or disease other than stiff joints of fingers.

Abdominal Wounds.—Chao Tei Shun, aged 33, had a gunshot wound of liver and other viscera. This patient was brought to my hospital during an absence previously mentioned. He had been wounded nine days before coming, and was brought a distance of 80 li (nearly 30 miles). His condition was very bad. Calomel, soda, and salts were given, and he improved so that he could take some nourishment, which he had not been able to do before. The following formula was prepared, and given in tablespoonful doses three times daily:

℞ Ammonii carbonatis, ʒi.
Olei terebinthinæ, fʒi.
Aquæ camphoræ, f℥ii.
Mucilag. acaciæ, q. s. f. f℥vi.
M.—Shake well before taking.

He was dressed carefully every day until my return, five days later, when I operated. I found a penetrating wound of the right side. This wound was enlarged, and, as the ninth rib was in the tract, the portion was excised subperiosteally, thus gaining access to the liver. The liver was found to be torn, and particles of the hepatic tissue were removed. No abscess was found in the substance of the liver. Irrigation with subnormal saline solution was used, and the wound was packed with gauze. His condition was such that a more radical operation was contra-indicated. The after-treatment was the daily irrigation of permanganate of potassium and peroxide of hydrogen. He was kept upon liquid diet, and was given castor oil and calomel frequently. A startling feature was the appearance before the operation of a worm in the wound, and in the after-treatment worms were found on several occasions. These were from four to eight inches in length, and were round, red worms, or *Ascaris lumbricoides.* They were all dead except one. That one was alive when it came out of the wound. Calomel and

santonin were administered and some live worms of the same kind were passed by the anus. I suppose there was a fistulous opening in the stomach and that the worms came from it. There was probably some passage of fecal matter with the worms when they made their way through the pyloric orifice into the stomach. It is a question with me whether there was a wound of the intestine, although there was fecal odor and some discharge in the wound. The absence of peritonitis and the length of time he lived would point at least to adhesions walling off the peritoneum. The internal wound remained open, and yet the connection with the hollow viscera seemed to close before he left the hospital. The fecal character of discharges ceased with the disappearance of worms, and but for his weakened condition recovery might have resulted. He was in the hospital from the 25th of May to the 30th of June, when his friends were advised to take him home; and he lived only two days after reaching there. It is hardly necessary to explain the preference of Chinese to die in their homes, even though removal be *in extremis.* We have found it best never to thwart our patients and their friends in this desire, but have been gratified to find some recently abandoning the custom. It is to be regretted that we are not able by postmortem examination to clear up many questions perplexing us during the life of the patient and which would be easily solved after death; but I have thought best in China to respect the wishes of friends with regard to this.

Another patient was brought to the hospital at the same time as the one just mentioned. The ball had entered the left side on the level with the left rib and passed out about the same level on the other side. The medical helpers thought the tract of the bullet lay subcutaneously, as they inferred from a line on the skin from the wound of entrance to the wound of exit.

The results proved that this was more serious. Calomel and soda were given without results. Enemas were also used, but no passage from bowels. Peritonitis with distention and temperature of 103° set up within six hours. The patient was taken from the hospital. On his way home he vomited blood, and died before reaching home.

Early in the revolution a soldier, aged 50, was shot in the right side, the wound probably involving both liver and stomach. He had been brought a long distance and was very weak. With the hope

of securing reaction and of operating and repairing the wounded viscera I administered morphia, grain ¼, and atropine, 1/150, hypodermically, and strychnine nitrate, grain 1/30. He did not react, but died within six hours of his admission to the hospital. His case was aggravated by a long ride in a shantza. No probing for the tract of the bullet was done. His pulse did not warrant giving an anæsthetic. I mention this case to show the caution that should be used in China before operating.

A case of nephrectomy for gunshot wound of the kidney occurred in Decatur, Ga., a town near the city of Atlanta. I was called soon after the injury and operated, removing the wounded kidney. He recovered from the wound and was presented to the Medical Association of Georgia, before which body I read a paper published in the *Transactions* of 1905. Up to that time Greig Smith had reported only five cases of this kind. W. W. Keen wrote me of his experience in this line. Keen's case, he wrote, was "the first one in which nephrectomy for gunshot wound was ever done." His case dated back to April 1, 1887, and was a part of laparotomy for pistol shot of the abdomen, involving the liver, the stomach, superior mesenteric artery and vein, small intestine, and kidney. Death occurred on the fifteenth day. His case was reported in the *Medical News* (Philadelphia) of May 14, 1887.

In my case the bullet was never removed. Yet the man had no inconvenience from it. In the cases reported by Greig Smith he does not state that they were gunshot wounds, but wounds of various kinds, two deaths out of the five.

W. M. Jordan, of Birmingham, Ala., reported, at a meeting of the Southern Surgical and Gynæcological Association, 1904, two cases of gunshot wounds of the stomach; one recovered, and one, a negro, died. Both were operated upon, and purse-string sutures were put in the wounds of the stomach. There was only one wound in the stomach of the white man to be closed. He thinks that a fold of the stomach may have allowed entrance and escape of the bullet; but it is also possible that the bullet remained in the stomach and passed off by the bowels. Such a case did occur in Georgia in 1892. Report of it is to be found in the *Transactions of the Medical Association* for that year. No operation, but probe, verified the presence of the bullet in the stomach and the bullet passed off by the bowels.

The man was able to be at work in a week. Only morphine and atropine and ice applications, with cathartic pills, had been given. This good result is explained by the wound being in the cardiac end of the stomach and no food in the stomach, with no extravasation. It is known that a wound in the stomach often closes automatically by pouting. The mucous membrane protrudes through the opening and acts as a valve.

It will be seen that in my own experiences I have given many cases of unfavorable results, hoping to gain light by discussion of difficult problems in treatment.

These conclusions may be drawn:

1. The location of a bullet is important to know, but not essential to first surgical treatment.

2. To delay operation after shock of wound has passed, and until suitable conditions are obtained, is advisable. Unless you are ready to operate and remove bullet, probing is not indicated.

3. After an unfruitful search for a bullet the bullet may become so loosened as to shift its position and come into a favorable location. Hence, delay is justifiable.

4. The earliest practicable removal of a bullet, when located, is the best surgery. The splintered or fractured bones should be first treated, then the soft parts.

5. The best treatment for penetrating wounds of the pleura and lung is to put the patient on the side affected, let the blood flow out of the wound, and then hermetically close one or both wounds. Keep the patient under morphia and atropine.

6. It will be noticed that no amputation has been done in the above cases for gunshot wounds. I have made it a rule to save limbs if possible. Quite a number of amputations of hands and arms were done during the revolution. Skill was shown in the performance of them, but I wish to enter my protest to primary amputation of members. With antiseptic precaution I think many cases may be saved. My impression from dealing with the Chinese themselves is that they have a repugnance to the loss of a limb, and it is probably a natural feeling. Since modern surgery should discountenance what was justifiable in the last century, we try to teach our medical helpers to save limbs.

THE TREATMENT OF HEMORRHOIDS *

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GENTLEMEN:—A male of forty years was admitted to the hospital three days ago suffering from painful hemorrhoids of the mixed type,—*i.e.,* not strictly external nor strictly internal. These hemorrhoids developed in the usual way, from anal irritation, preceded by constipation, then there occurred a break in a small blood-vessel, forming a clot in the tissues.

Remember that a hemorrhoid develops from the solution of continuity of a small blood-vessel just within the anal verge, with formation of a clot beneath the surface, usually as a result of irritation or obstruction to the fecal outflow. Another vessel may be later abraded from similar cause with the formation of another clot, and so on until (as in this case) the hemorrhoids entirely surround the anal opening, and, the irritation persisting, the hemorrhoidal tumors naturally continue to increase in size. When the clots become organized,—*i.e.,* when formation of connective tissue supervenes,—there is no possibility of the hemorrhoidal tumors being resorbed. In some instances this occurs rapidly, in others slowly, depending upon the habits of the individual, the presence or absence of constipation, the care devoted to the part, etc. In those who are habitually constipated the condition rapidly becomes aggravated, and when there is pruritus ani or an anal discharge of irritating mucus or pus due to a fistula or an ulcerated surface, naturally the development of hemorrhoids is quite rapid. In those instances, however, where such aggravating conditions do not obtain, hemorrhoidal development may be more gradual.

He was given the regulation preparation, which, in brief, is: The administration of a purgative the second night preceding the date of

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* Clinical lecture delivered before the Senior Class of the University of Louisville, Medical Department, at the Louisville City Hospital.

operation. There is no particular character of purgative to be recommended; any drug which will thoroughly cleanse the primæ viæ will suffice,—*i.e.*, a large dose of calomel followed by a saline, a large dose of castor oil, or two or three compound cathartic pills. The next day a large soapsuds enema is given, thus still further cleansing the sigmoid and rectum. It is desirable to have the rectum free from fecal matter and as clear as possible from all micro-organisms which might give trouble following the operation. The colon bacilli and other pyogenic organisms should be eliminated so far as may be practicable. A second soapsuds enema should be given three hours before the appointed time for the operation. The balance of the preparation is the same as that for any other surgical procedure to be undertaken upon the rectum. The patient is given no breakfast, has the regulation bath, etc., and is then brought into the anteroom for administration of the anæsthetic, after which he is placed on the operating table. The operative field is again scrubbed, inside as well as around the anus, and the parts are shaved.

When the patient is ready the first step is to determine if the anæsthesia is sufficiently profound, since, as is well known, for any operation upon the rectum complete anæsthesia is required. The next step is introduction of the finger into the rectum and through the sphincter muscle, which should be accomplished slowly and carefully to avoid tearing the mucous membrane or causing damage to structures within the anal verge which are not already implicated. When the finger has been introduced and the sphincter muscle pressed upon in all directions, if anæsthesia is complete the muscle begins to relax; if anæsthesia be not sufficiently profound the muscle will contract upon the finger, which means waiting a few minutes for more complete anæsthesia. When the sphincter begins to show relaxation, with more vigorous movement the operator's finger divulses the sphincter muscle; then a second finger of the same hand or the forefinger of the opposite hand is introduced, massaging and stretching the muscle, this being continued until the capacity of the sphincter is reached. This is easily determined after a little experience, but it must be remembered that in some individuals the muscle will stretch to a much greater extent than in others. To avoid damaging the sphincter a speculum should not be utilized for this purpose; it is

better to use the fingers, because when a speculum is forcibly opened fibres of the muscle may be torn.

When stretching of the sphincter muscle has been completed, remove the fingers and, if there is any mucus or other evidence of lack of cleanliness of the part, again irrigate the rectum and dry it with gauze. It will be found that even internal hemorrhoids can be easily everted if the sphincter muscle has been thoroughly stretched. If the anæsthesia is sufficiently profound, the sphincter muscle will remain relaxed long enough for the operation to be completed.

When the hemorrhoids have been everted the method of their removal must be decided, and ordinarily the largest one is selected first. Some surgeons state that the largest tumor is more often in the left anterior quadrant, others in the right anterior quadrant, etc., but according to my own experience no invariable rule can be formulated, as the site varies with each individual case.

There have been many procedures devised for the cure of hemorrhoids, some of the text-books describing as many as thirteen separate and distinct operations to accomplish the same result. It is unnecessary to outline all of them, since there are but three of importance, and one or the other of these will be applicable to any case. In passing it may be said that several of the thirteen procedures mentioned could not be consistently recommended by any rational surgeon of the present day, one of these being the so-called crushing operation devised by a French surgeon many years ago. He claimed that by seizing the hemorrhoid in strong-jawed forceps and completely crushing its substance a complete cure could be obtained. Undoubtedly by this means the hemorrhoid would be destroyed, but just as certainly the resulting wound would be objectionable, and there is no argument in favor of the operation when there are cleaner and more rational surgical procedures. One of the dangers is the same as that urged against the majority of the other undesirable methods of operating upon hemorrhoids,—*i.e.,* the probability of infection. The crushed dead tissue, in sloughing, would come in direct contact with healthy living tissue and infection would be quite likely.

Another of the thirteen operations which is undesirable consists simply in completely divulsing the sphincter muscle, advocates of this method claiming that hemorrhoids could be cured by this means alone.

It is now well known that this is a mistake, and the idea was evidently based upon a misapprehension as to the true nature of hemorrhoids. It is true that a small anal fissure or slight inflammation or congestion may be relieved by complete divulsion of the sphincter muscle, but a hemorrhoidal tumor will not be resorbed after this method of treatment.

All varieties of hemorrhoids can be successfully treated by one of three methods, one being more appropriate in a certain instance than another: (1) The excision operation,—*i.e.*, wherein the hemorrhoids are completely excised and the wound closed by immediate suture. After all hemorrhoids have been thus treated, and hemorrhage controlled, the anus is carefully cleansed of any discharge, an anal dressing tube is introduced to afford protection from infection, and an outer dressing applied. (2) The clamp and cautery operation. (3) The third, which is perhaps employed oftener than any of the others, is the modified ligature operation, and the method which will be utilized to-day.

The modified ligature procedure differs from the ligature operation devised many decades ago and still used by some surgeons, solely in the depth of the cut around the hemorrhoidal tumor. The ligature operation consists of a cut beginning at the mucocutaneous junction on one side of the hemorrhoid and extending around the base to the mucocutaneous junction on the opposite side, this cut simply being made entirely through the skin. Where the hemorrhoids are large this necessitates constricting with the ligature a considerable amount of tissue, the ligature being placed in this groove and tightly tied. In some instances transfixion of the mass is practised in order that the pedicle ligated may not be so large. This procedure is no longer to be recommended, since by the modified ligature operation the same purpose may be accomplished, the patient being spared a great deal of pain, the time necessary for convalescence is lessened, and it is in every way more surgical. To repeat, the modified ligature operation is the same as the ligature operation except that, instead of stopping with the cut around the base of the hemorrhoid when it has gone only through the skin, the cut is continued through the tissues down to the large blood-vessels which are always located just under the mucous membrane. The structures ligated consist simply of mucous mem-

brane and the large blood-vessels, together with, perhaps, a small amount of submucous tissue. In this way, no matter how large the hemorrhoid may be, the pedicle will be comparatively small.

The object of the ligature in both these operations is simply to control hemorrhage from the large vessels and to prevent retraction of the mucous membrane. As the modified ligature operation accomplishes exactly the same purpose, obviously it would be inadvisable to constrict a large mass of inflammatory tissue containing numerous nerve-fibres, which, having to be cut through by the ligature, would cause the patient great discomfort for several days, when this tissue can just as well be divided with scissors and the ligature applied deeply in the cut.

It should also be remembered that in the removal of hemorrhoids only the tumor, and nothing more, should be extirpated, and in doing this it is well to introduce the forefinger of the opposite hand into the anus to determine the uppermost margin of each hemorrhoid. A pair of ordinary surgical scissors, curved on the flat, may be used in making the dissection around the tumor, not going sufficiently far inward to include any structure that is not hemorrhoidal, nor so far from the anus as to leave a portion of the tumor itself, carefully dissecting the hemorrhoid from the surrounding healthy structures, making the cut down to the large vessels, applying the ligature and tying tightly. Each hemorrhoid is treated in this manner, and after ligation is completed forceps are attached to the outer extremity of each ligated tumor. Then the dressing tube is introduced into the rectum, the hemorrhoidal masses being then cut away, leaving only a sufficient stump to be sure that the ligature will not slip, after which small strips of gauze are packed between the raw surface and the outer flange of the anal dressing tube; a pad is then placed over the dressing tube, and a "T" bandage applied, or the perineal bandage is preferred under some circumstances. The patient is returned to bed, and as soon as he awakens one-fourth grain morphine and 1/150 grain atropine are administered hypodermatically, to induce quietude. However, morphine is recommended not so much to control pain, which is not great if the operation be executed in the manner described, as to lessen peristalsis and prevent defecation earlier than is desired. The outer dressing is removed at the end of twenty-four hours, the gauze inserted between the raw surfaces, and the tube is allowed to remain

forty-eight hours; the tube is left *in situ* for four days, and when removed a purgative is given to induce free alvine evacuation, after which defecation takes place regularly each day.[1]

If the operation has been completed according to the suggestions herein contained, the patient thereafter suffers little pain, and the ultimate result is practically assured,—*i.e.*, the patient may be promised absolute relief.

The patient now being ready, by introducing the finger into the rectum we find anæsthesia is sufficient: the sphincter muscle begins to relax at once. The introduction of two fingers produces still further dilatation, and with the forefinger of the opposite hand the sphincter is then massaged and stretched to its normal capacity, just as would result from gentle mechanical divulsion. Note the difference in color of the exposed mucous membrane, that which covers the hemorrhoids being dark and congested, while that of the rectum proper is of normal color.

The extent of the hemorrhoidal development is determined by the fingers after the tumors have been everted. With the thumb outside and the forefinger inside the rectum, the hemorrhoidal tumor can be grasped between them. Where the base of the hemorrhoid is large it may be ligated, if desired, in two sections, instead of placing one ligature around such a thick pedicle which might constrict so much tissue as to ultimately result in a contracted anal opening. In this case the hemorrhoids extend entirely around the anus, and they will be ligated separately, as hereinbefore suggested.

The rectum is found perfectly clean, there being present no fecal matter, mucus, nor pus, showing that preparation of the patient has been adequate. The largest of the tumors, which happens to be on the right side, will be ligated first. The most important feature is to determine just where to begin making the groove for the ligature. With the forefinger of the left hand it can be ascertained just how high this hemorrhoid extends. Lifting the tumor with the finger, the cut is commenced at the proper point and extended to the opposite side, the skin retracting as the cut is made at the junction of the mucous membrane. By pressure of the finger it can be determined when the

[1] The anal dressing tube referred to was devised by the writer about four years ago, and has since been used with universal satisfaction. It is known as the "Asman Anal Dressing Tube."

large vessels have been reached. In the event a vessel is severed, as occasionally happens, it may be caught with forceps and included in the ligature, or may be ligated separately. The pedicle has been markedly reduced, there remaining only the mucous membrane and the blood-vessels. A strong ligature consisting of cotton and linen is placed around the base of the hemorrhoid, care being exercised to be certain that it extends well into the groove made as described, the reasons for which are obvious, and it is then tightly tied on the inner side. The tighter the ligature is drawn the more quickly the nerve-fibres in the included tissue will be destroyed. When the ligature is tied all hemorrhage ceases from the branches of the vessels, and there is now simply slight capillary oozing from the edge of the skin which pressure of the dressing will control. Having thus finished with one hemorrhoid, the next is similarly treated, and so on until all have been ligated.

The question has been asked if an operation of this character could be successfully performed under local anæsthesia. I would not care to undertake the modified ligature operation for hemorrhoids under local anæsthesia, where the tumors were as large and as numerous as in this case, unless it were absolutely necessary. If there were good and sufficient reasons, however, for not employing a general anæsthetic, the operation might be successfully performed under local anæsthesia, but, of course, it would not be nearly so satisfactory.

In cutting around one of the hemorrhoids a large blood-vessel has been accidentally severed, which is immediately clamped with forceps and will be included in the ligature. This is an accident which will sometimes happen despite the utmost care to prevent it. However, it amounts to little, as hemorrhage is easily controlled.

With further reference to the question concerning local anæsthesia: Where patients cannot safely take ether or chloroform, it has been my practice to use nitrous oxide gas. There are few people who cannot safely take gas, and an operation such as this can usually be satisfactorily performed under gas anæsthesia. Not long ago I operated upon an exceedingly large, fleshy man who had some heart lesion, and it was considered unsafe to administer ether or chloroform. Several large hemorrhoids were removed under gas anæsthesia. However, under this method of producing anæsthesia relaxation is not always as complete as might be desired.

An important point to be borne in mind in the performance of the modified ligature operation for hemorrhoids is to avoid undue constriction of the anus. In this case the anus is well open. The last of the hemorrhoids having been ligated, forceps are attached to each of the ligated tumors, and the anal dressing tube is inserted after trimming away the excess tissue comprising the tumors and also any skin-flaps present. Hemorrhage has ceased with the exception of slight capillary oozing along the skin margin, which will be readily controlled by pressure of the dressing. There are two or three small flaps of skin which must be trimmed away, because if permitted to remain they might be the cause of future trouble. Gauze is inserted between the flange of the anal dressing tube and the raw surface; over this will be placed a gauze pad, and then the usual "T" bandage.

It may be confidently expected that this patient will have an uncomplicated convalescence and be able to leave the hospital within ten days.

Eugenics

CONSTITUTIONAL IMMORALITY *

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A VAST wealth of clinical material of psychiatric nature is going to waste in our penal institutions because of a lack of scientific curiosity on the part of well-qualified investigators. Among the interesting and intricate problems met with in prisons and reformatories is the subject of constitutional immorality, the obscure and difficult pathology of which offers a most inviting field for study and research to the alienist and criminologist. The idea that some individuals are immoral because of constitutional defect of the neural organism is most repugnant, as it seems to challenge the traditional belief in man's free will, and this is especially true of those unfamiliar with mental diseases.

Yet we who have delinquent individuals within our care and custody know that there are persons who cannot refrain from crime because of their degenerate organizations, which predispose and impel them to immoral and illegal acts.

Before going further, it may be well to speak of morality or the moral sense in the general acceptance of this term. Every individual is presumed to be the possessor of an innate moral sense or conscience, which enables him to decide as to what is right or wrong in human conduct, and act accordingly. Morality and character may be described as a function of the brain, as is memory, imagination, or thought; and it is certain that no life is lived without the development of what we term character.

The moral sense or quality is, however, the last of the psychic

* Read at the Alienists and Neurologists' Convention, held in Chicago, June, 1913.

functions to be developed; it is also the first to be confused, disordered, or destroyed by pathological processes affecting the mind.

It is perfectly apparent that the function of intellection may be limited by developmental defects occurring in the physical evolution of the brain substance; this being the case, there is no logical reason why the moral capacities of the mind should not suffer from defect for the same reason.

Since well-qualified observers have found to be an entity a condition which has been variously termed constitutional immorality and moral insanity or moral imbecility, it will be apropos to quote several definitions describing it.

Tanzi states, "Constitutional immorality is recognized . . . ; in such instances the faults of character are out of proportion to the insignificant disorders of intelligence."

White defines this condition as follows: "Moral imbecility is a condition of mental defectiveness which is shown by the absence of the highest functions, particularly the moral; capable of training to a considerable degree, but always a menace to society." Maudsley speaks of cases of this kind as "a group of persons of unsound mental temperament, who are born with an entire absence of the moral sense, destitute even of the possibility of moral feeling; they are as truly insensible to the moral relations of life, as deficient in this regard, as a person who is color-blind is to certain colors, or as one without the ear for music is to the finest harmonies of sound. Although there is usually combined with the absence of moral sensibility more or less weakness of the mind, it does happen in some instances that there is a remarkably acute intellect of the cunning type."

According to Herbert Spencer, higher feeling is merely the centre of coördination, by which less complex aggregations are brought into proper relations. In the process of evolution, this centre of coördination may never be developed, and moral insanity may result, or great waywardness of moral conduct without marked disorder of the intellect. The doctrine of moral imbecility and moral insanity is then, as Tuke says, "in full accord with mental rules of evolution and dissolution as laid down by Spencer."

Spitzka has defined constitutional immorality as follows: "Disorders of the moral sentiments may be congenital . . . , an original deficiency analogous to that lack of musical sense or color-blindness

which may coexist with a fair faculty of language and good contour of perception . . . , with fairly good logical powers in the abstract." According to Sir James Crichton-Browne, "The moral imbecile is a person who by reason of arrested development or disease of the brain, dating from birth or early years, displays at an early age vicious or criminal propensities which are of an incorrigible and unusual nature, and are generally associated with some slight limitation of intellect."

GENERAL CONSIDERATIONS

The operation of the indeterminate laws which are so generally in force separate the accidental and occasional criminals from those who are constitutionally immoral. The first class is composed of those persons who have strayed from the paths of moral and legal rectitude while under the strain of some unfortunate circumstance which provokes an outburst of passion; an individual in whom the social tendencies are strongly developed might commit a murder in the heat of passion to avenge a sexual outrage on a member of his family committed by an anti-social person. A too free indulgence in alcoholic beverages or association with vicious companions may lead to crime in persons who do not differ from the normal members of society. These persons regain their former standing in civil life, and forget their crimes, which were merely solitary and incidental experiences in their lives. The constitutionally immoral serve sentence after sentence, are paroled again and again to the best of environments, but they cannot be kept out of prisons, toward which they gravitate, irresistibly drawn to them by inherent defects in their constitutions.

These unfortunate moral defectives we generally find to be burdened with an evil heredity, a harsh, unrelenting tyranny of ancestral defect. Many of them are ignorant, and do not rise above the level of the feeble-minded; in marked contrast, others are highly-educated persons who assent to general propositions concerning right and wrong, and frequently delight to discuss moral customs and laws in order to exploit their casuistic and argumentative powers, but to them the concrete application of moral or legal restraint is a hard saying which they cannot understand.

Some of the highly intellectual immorals fail to display the

grosser and more vulgar evidences of their defects; their moral anæsthesia shows itself in an absence of the desire to do good, and a poverty of altruistic sentiments. They conform in a negative manner to the conventions of society for personal gain alone. They regard marriage as legitimate prostitution. They perform acts of apparent charity to gain personal advertisement; make various professions of religion to suit the community in which they may happen to live, if they find it pays; again they pose as humanitarians or public leaders for the satisfaction of their exaggerated egotism.

"They are, nevertheless, immoral persons without honor, without remorse, without feeling, without passion, and without humanity. They never yield to the cruder forms of crime; they are furious at the slightest suggestion that they are immoral."

The greatest criminals to-day belong to the highly-educated type whose crimes are so cunningly executed and who are so veneered with an appearance of respectability that for long periods of time we fail to discover their moral bankruptcy.

MECHANISM OF CONSTITUTIONAL IMMORALITY

The processes of the mind are continuous, and so-called faculties or states of mind have no separate and distinct existence; yet the terms of the old psychology may be used conveniently in this paper to designate those three great expressions of mental life, intellection, feeling, and volition. These are conjoined and blended continuously, and no one of the three can be taken into account without considering the other two. So, in my endeavor to describe moral insanity, I will classify it under three heads, according to which one of the three great functions of the psyche is most involved. We may, therefore, divide constitutional immorality into four types, as follows:

1. Where the defect of the psyche is most marked in the sphere of intellection.
2. Where the defect is most pronounced in the emotional sphere.
3. Where the volitional sphere is primarily involved.
4. Where more than one sphere of the mind is affected.

The function of the mind is continuously to adjust the individual to his ever-changing environment, and a proper balance of the intellectual, emotional, and volitional activities is necessary for this adjustment. In the constitutionally immoral we find a disequilibra-

tion * of the above-mentioned functions of the mentality which leads to the consummation of the criminal acts. A bank robber skilfully opens a most intricate lock to a vault and secures its valuable contents. The criminal's intellectual capacities were adequate to the understanding of the mechanism of the difficult lock, the necessary volitional activities were evidenced by the skilful manipulation of the same and the successful completion of his well-calculated crime, but the much-lowered or inert emotional capacities of his mental organism failed to exert a proper moral inhibitory influence. Disproportionate activity of the intellectual and volitional attributes of the psyche over the emotional qualities resulted in a decidedly abnormal reaction. This illustration does, no doubt, seem to be quite extreme, yet it very adequately fits some cases of criminality with which I am familiar.

IMMORALITY DUE TO DEFECT OF THE INTELLECTUAL SPHERE

There is a wide range in this form which extends from imbecility to a condition of high-grade feeble-mindedness. The individuals who belong to this class fail to see, because of their mental deficiencies, the relation they bear to other individuals, so far as moral and legal obligations are concerned. The crimes of this class are homicides, assaults, rapes, and petty thefts.

IMMORALITY DUE TO DEFECT OF THE VOLITIONAL SPHERE

This form is one of the most striking and interesting in the field of morbid psychology, and it is to be regretted that these individuals of defective will power are more studied and observed by our legal friends than by the physicians. These persons are easily influenced; they know the difference between right and wrong, and yet are unable to suppress or restrain their inclination to crime; they frequently experience explosions of anger, and at these times commit most atrocious and barbarous offences against the law. Often they are of remarkable intelligence and mental training, and no better descriptive term can be applied to them than that of "black sheep."

The defects of the will may be arbitrarily classed under three heads:

1. The explosive will.—This condition is due to defective in-

* Disequilibres.

hibition of the intellectual and emotional impulses which restrain the activity of the volitional sphere. Persons of the mercurial type with their hair-trigger temperaments are familiar to us all. In these individuals the motor impulse is translated into criminal acts before their defective mental mechanism can release the inhibitory social impulses.

2. Exaggerated impulsions.—Criminal acts are committed where the normal amount of inhibitory power is present, but is insufficient to overpower the pathological and exaggerated impulses which lead to criminal acts. To this class of moral defectives belong the dipsomaniac, kleptomaniac, and pyromaniac; when attempting to resist their impulsions these persons experience such physical symptoms as prostration, tremors, and vertigo which disappear when the impulsive act is performed. Unfortunate individuals of this type are aware of the morbidity of their acts. James relates the following case: A tippler who, after making several unsuccessful attempts to secure liquor, had deliberately chopped off his hand, then called for a bowl of rum, which was obtained for him, and into this he plunged the bleeding member, and then drank the liquor, following the act by the exclamation, "Now I am satisfied." Another dipsomaniac made the following statement: "If a bottle of brandy stood at one hand and the pit of hell yawned at the other, and I were convinced that I should be pushed in so surely as I took one glass, I could not refrain." Similar statements are frequently heard by those who come in contact with inebriates.

3. Arrest of the will, or abulia.—This defect, we find, may be due either to an excess of inhibitory ideas or to a lack of sufficient volitional impulse to perform the social duties demanded by society. In this condition the intellectual and emotional spheres are usually nowise affected, but the connecting link between these two or the emotional sphere seems to be lacking. The crimes or misdemeanors resulting from this defect are sins of omission rather than commission. To this class of psychopathic characters who display many anomalies of mind and mood, whose psychological tensions are lowered, and whose mental perspectives are distorted, may be assigned the vagabonds, prostitutes, fakirs, and deadbeats. Their lives are classically described by Regis as being "one long contradiction between an apparent wealth of means and poverty of results."

IMMORALITY DUE TO DEFECT OF THE EMOTIONAL SPHERE

In this form the primary or greatest defect of the psyche seems to be in the emotional sphere. The defect of the emotions may be divided into two varieties, in one of which there is a condition of transient and ephemeral hyperactivity of such emotions as anger, hatred, jealousy, and eroticism which leads to atrocious and abhorrent acts of cruelty. In the second variety we find that the emotional defects are evidenced by a cold, heartless, and indifferent paucity of ethical sentiments. We find in this class men of excellent education and others who, though not conventionally educated, are keen and cunning and possessed of an abundance of native intelligence. Among the immorals of this type are the skilful forgers and swindlers who practise their art of fraud so carefully that they are able to cover their heartless depredations with a cloak of legality and respectability. To this same species of criminals belong the professional gambler, the avaricious capitalist who corners the necessities of life, and the absconding bank cashier who steals and squanders the savings of small depositors without one pang of conscience or remorse. I do not wish to be understood as saying that all persons who commit such crimes are abnormal, and we should be exceedingly slow to pronounce them irresponsible and undeserving of imprisonment. Tanzi employs the following analogy to describe them: "As there are dogs without scent and flowers without perfume, even so also are there persons devoid of benevolence and sympathy."

I have selected the following cases of constitutional immorality to illustrate each of the four types that I have enumerated. The first case may be classified under that form where the greatest defect of the psyche is shown in the emotional sphere. In this one we find an absence of sympathy and other altruistic qualities, an excessive egotism, and a capacity to inflict physical pain on others in the most predatory manner.

Negro, 29 years of age, convicted of murdering his common-law wife. One brother insane. Physical examination: General functions of the body normal; health excellent; physical signs of degeneracy present; head of the plagiocephalic type; marked inferior prognathism; malocclusion of the teeth; palate low, flat, and irregular.

The following is the prisoner's own story of his crime, which he tells in a most indifferent and careless manner which offers abundant

proof that he is morally anæsthetic: "She commenced fussing about nothing, and then tried to hit me with a rock, but I caught her, and she lay her head upon my arm in the same way as a chicken's head on the block, like she did not know anything. I then bear down on the razor, and had to get the blood out of my eyes which made me blind. After this I walked around the house, and told the neighbors that I had killed May. I then went into the house, washed my face and finished dressing, fixed my breakfast, and before I had finished eating the police came and got me. Never felt sorry, conscience never hurts me, don't feel guilty of doing any wrong, didn't do any wrong, I ought to be free. The only thing wrong about it is that I ever came to Indiana."

The prisoner has intelligence equal to the average of his race. Mental processes a little slow; memory good for past and recent events; is perfectly oriented as to time, place, and person. He has no delusions or hallucinations; takes an active interest in his fellow-prisoners; reads library books and magazines to a considerable extent. He will not work, and prefers absolute idleness to employment. He is so constituted that he is devoid of any sense of moral or legal responsibility, and is therefore a dangerous individual, and should be detained permanently in a hospital for the criminal insane.

IMMORALITY DUE TO DEFECT OF THE EMOTIONAL SPHERE

Prisoner a white man, 27 years of age, born of wealthy parents and afforded every opportunity for success in life. Prisoner had the usual diseases of childhood. He graduated from the common schools at 15, had played truant at school, and was self-willed and stubborn as a child. He has indulged freely in alcoholic beverages.

This prisoner tells in a very glib and theatrical manner the way in which he killed his mother for the purpose of obtaining money which she carried about her person. Prisoner entered the kitchen where his mother was preparing dinner, and without saying a word struck her with a hammer on the occiput. After she fell he removed from her person one hundred dollars and a diamond ring; he then went upstairs to cleanse his hands and rearrange his clothing. While in his room he heard his mother groan and, fearing that she should make some outcry, he returned to the kitchen, where she lay unconscious and prostrate on the floor, and deliberately fractured her skull

a number of times with the hammer until he was certain that she was dead.

Prisoner is oriented as to time, place, and persons; his memory is good for past and recent events; his answers to questions are coherent and relevant; delusions and hallucinations absent. He displays an excessive amount of egotism; he affects some remorse and sorrow for his atrocious crime, but this veneer of remorse is so studied and superficial that it is easy to see that it is feigned for the purpose of impressing his observers with the idea that he has reformed.

CONSTITUTIONAL IMMORALITY DUE TO DEFECT OF THE VOLITIONAL SPHERE

Prisoner is a burglar, 44 years of age. His mother died of brain tumor. He received a common-school education. He never has indulged in alcoholic beverages, but has been convicted ten times for larceny, robbery, and burglary and, altogether, has spent 18 years of his life in prison.

Prisoner is oriented as to time, place, and person; intellectual operations are prompt and accurate—he has no hallucinations or delusions; he knows right from wrong, and that punishment will follow his crimes, but withal he is unable to control his actions when he becomes possessed with an irresistible impulse to commit a theft. He offers the following explanation for his crimes: "I can work very well for several months, then I become possessed with an irresistible desire to steal and rob. This desire is so intense and powerful I cannot resist it. After committing the deed I experience great relief and satisfaction. I feel no particular remorse or sorrow for my deed, but I do have considerable anxiety and dread that I will be caught."

IMMORALITY DUE TO DEFECT OF THE EMOTIONAL SPHERE

White man, wealthy farmer, 35 years of age, reached fifth grade in school. This prisoner adopted a 14-year-old boy from an orphanage. One day in a fit of violent anger he bit and mutilated the child's body in 200 places. His victim died in two hours after this barbarity. This convict is stolid and phlegmatic, but occasionally displays periods of excessive anger. He attempts to justify his crime

by saying that the boy was stupid, and worried him continually by breaking his farm machinery and his tools.

IMMORALITY DUE TO EMOTIONAL DEFECT; INTELLECT ABOVE THE AVERAGE

Prisoner is 55 years of age, a graduate of the Phillips Academy at Exeter; was surrounded with every advantage and social opportunity during his childhood and youth, and his crimes in no way can be charged to his environment. After graduating from the Academy he was given an excellent position in a manufacturing establishment. At this time his inherent tendencies began to display themselves. He commenced a system of robbery and thievery which he has followed throughout his entire life. He has swindled company after company by making false entries on their business ledgers, forged checks, and floated wildcat schemes, but owing to his keen intellect, diplomacy, refinement of manner, elegance of appearance, and shrewd business ability he managed to keep out of prison until two years ago, when he was convicted and sentenced to the Indiana State Prison for forgery. At that time he was commanding a salary of nearly five thousand dollars, and there was absolutely no other incentive for forging or robbing except the satisfaction of his inherent desire to defraud. He neglected his invalid wife and family while he lavished money upon a public prostitute whom he took on a pleasure trip to Japan, where he resided for two years, living on forged and stolen moneys in extravagant style. This prince of forgers is a model prisoner, and is now employed as expert accountant in the prison office. At the present time there are nineteen indictments against him for forgery in various States. The field of his criminal operations extended from New York to California. He never displays any remorse or sorrow because of his wholesale swindlings and frauds, but feels that a man of his keen business ability is being very much imposed upon because he was not released at the expiration of his minimum sentence to practise further depredations upon the stupid public.

EMOTIONAL DEFECT TYPE OF IMMORALITY

White man, 46 years of age; claims to have a college education; he has twice been convicted of bigamy and three times of forgery; he has been a ne'er-do-well and deadbeat all his life; has tried nurs-

ing, soliciting, lecturing, writing, preaching, and numerous other fields of activity, and has signally failed at each of them. He was not content to confine his fraud and forgery strictly to the financial sphere, so he three times forged ordination papers to preach the Gospel. His deceptions were discovered by his ecclesiastical associates, and he was promptly deposed from the ministry; then, as his inherent criminal tendencies were stronger than his inclination for honest work, he resorted to his old occupation of forging checks. This prisoner is a good conversationalist, and by his suave and diplomatic frankness secures entrance into the most exclusive circles, which promptly suffer from his wily schemes and inborn crookedness.

While under my observation I found him to be a pathological liar. It seems that he cannot tell the truth even when veracity would be of greater advantage to him. He does not hesitate to practise the lowest forms of calumny, backbiting, and deceitfulness, which stand out in marked contrast to his religious pretensions.

DIAGNOSIS

The diagnosis of constitutional immorality is by no means easy or even always possible, and a careful investigation and consideration of the individual's full life-history is absolutely essential. His life must be reviewed from infancy, and full weight be given to the influences of environment, education, standards of living, and the character of the reactions to the same.

We must be most careful that we do not stigmatize as born criminals intelligent prisoners who may through some unfortunate circumstance or some legal error find their way to prison. Again, we must be exceedingly slow to pronounce as irresponsible those violators of the law who wilfully resort to crime for personal aggrandizement, lest we make a farce of our present judicial system, and thereby endanger the public safety. We must distinguish constitutional immorality from those crimes and misdemeanors which are so often a part of the symptom-complex of essential insanities. The motives and circumstances connected with the crimes associated with ordinary mental diseases generally bear the impress of marked mental derangement, and such crimes are rather characteristic.

The crimes of epilepsy are the most difficult to differentiate from those of constitutional immorality, and, in fact, some moral defective-

ness has been thought to be an expression of epilepsy itself; in accordance with this view, Lombroso described criminality as a form of epilepsy, but this position is not altogether tenable.

The criminal offences of epilepsy are homicides, thefts, assaults, arsons, and rapes. Clouston has said, "Murder by an epileptic should be looked upon as being as much a symptom of his disease as is larceny by a general paretic." The criminal acts of the epileptic are frequently committed in the automatic states which precede or follow a paroxysm; such acts often seem to be the result of coherent and conscious volition, but when the individual regains his normal status we find that there is an amnesia for the period during which the crimes were perpetrated. In states of psychic epilepsy consciousness is many times retained, but responsibility is lacking because of an inertia of the volitional sphere or an insufficient release of inhibitory impulses. The epileptic neurosis must always be considered when some apparently normal person commits an outrageous and cruel act without assignable motive.

Constitutional immorality must be distinguished from the symptoms which attend the prodromal period of hebephrenia which is marked by extreme wilfulness, incorrigibility, impulsive assaults, and sexual crimes. Gradual mental deterioration and progressive indifference to environment will serve as diagnostic factors. The heboidephrenia of Kahlbaum offers another difficulty for differentiation; here we find little or no evidence of progressive deterioration. The misdemeanors and petty crimes constitute the chief symptoms of this psychosis, but the average puerile intelligence and the pettiness of the misdemeanors are such as to distinguish this type from the intellectual and educated moral defective whose violations of law show a keenness of intellect.

The crimes associated with senile dementia are acts against public decency, rape, foolish thefts, and suicides. The crimes attendant upon arteriosclerotic dementia are practically of the same character, with the addition of arson and homicide. Persons suffering with paranoia frequently commit homicides, assaults, and blackmail. The crimes and offences of general paresis are so pathognomonic that there is little chance for them to be overlooked. As a rule, they are foolish and absurd actions. The patient afflicted with the expansive type of this disease undertakes impossible financial opera-

tions and indulges in wild speculations without apparent knowledge of the quality of his acts. Debauchery and lewdness usually attend paresis. The nervous phenomena and the positive Wassermann reaction of the blood and spinal fluid render the diagnosis easy and certain.

TREATMENT

The specific treatment of the constitutionally immoral is very difficult for various reasons. Our prison populations are heterogeneous masses composed of insane criminals, epileptic criminals, feeble-minded criminals, habitual criminals, occasional criminals, and criminals by passion, and they are all subject to the same discipline and treatment. Now it is the crime that regulates the term of imprisonment, and not the needs of the criminal. The imbecile offender is condemned to the same rigors of the law as is the educated man, when convicted of the same statutory offence. Our courts are exceedingly loath to recognize constitutional moral defectiveness lest it weaken our methods of dispensing justice, and thereby jeopardize the safety of society. Physicians will, no doubt, at some time in the future be asked to give to our criminal courts such data concerning the prisoner's physical and mental status as will lead to a more scientific dispensation of equity. There is no need, however, that our courts become medical clinics, and never should medicine attempt to usurp the prerogative of the law. The proper scientific classification of the prisoners is too ideal to be obtained under the present-day administration of penal institutions.

Several methods of treatment have been offered for the morally insane, but none as yet have passed the limits of the experimental stage. These may be briefly mentioned.

Why should not the born criminal remain in prison so long as he is dangerous to society? We do not release the violent and dangerous insane from hospitals merely because they have been detained there a number of years; then why should we release the instinctive criminal to practise his criminal acts upon the public? We quarantine smallpox, and we exile the leper; then why should we not isolate the incurable moral defectives who disseminate dangerous moral contagion? The question of sterilization needs no other attention than to be mentioned, as it is being brought before the public in the most active way, and, no doubt, when the mists and miasma

of superstition and ignorance which now enshroud the subject of heredity have been cleared away, sterilization will no longer be regarded as a predatory measure.

Craniectomy has been tried in children with success in some cases and failure in others. The procedure is not altogether warranted, and to be of any use at all the operation must be performed very early in life, at a time when we are unable to judge accurately of the moral character.

Lugaro has suggested that the impulsivist should have his thyroid gland mutilated,—care being exercised that the parathyroids are not injured,—with a view to bring about a mild degree of intoxication, not unlike that found in myxœdema, which would calm and allay irritable and impulsive tendencies without impairing the integrity of the intellectual capacity. This measure is not being carried out, so far as I know, and before attempting it, the physician should make sure of his legal protection.

We seek to detect abnormalities in the children and, should we find deviations toward criminal tendencies, place them in a healthful environment, and give them such schooling as will particularly develop their social instincts and tend to compensate for their inherent defects. The prognosis, however, is bad, for no amount of training will alter or long hide the vices of organization.

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SHALL THE DEAF-MUTE REMAIN DUMB OR SHALL THE DUMB SPEAK?

FROM THE LETTERS AND PAPERS OF FRANCES WETTSTEIN, PRINCIPAL OF THE SCHOOL FOR THE DEAF, MILWAUKEE, WIS.

BY CARL THEODOR WETTSTEIN

"Don't pity the deaf; make them happy."—CARMEN SYLVA, Queen of Roumania.

"Teach them to speak like hearing people do."—DR. ALEXANDER GRAHAM BELL.

AMONG the many institutions for the physical and intellectual improvement of defective children, the schools for the deaf are among the most prominent. We find them in every large city and in many smaller ones. These schools are divided by two methods, as we would call them. In one the well-known sign or French method is taught; in the other the oral or German method. The latter teaches a deaf child to speak as hearing people do, by reading the words from the lips of the speaker.

In New York deaf-mutes are educated by three different systems, each school claiming superiority of its method over the others. In Enoch Henry Currier's school in New York City the "combined" or "electic" method is in use. In the school of T. F. Westervelt, Rochester, N. Y., the "manual alphabet" predominates, and in E. H. Gruver's school, New York City, teaching is by the "oral" method. New York City has recently followed the example of Wisconsin and established "Public Day Schools for the Deaf." Wisconsin was the first State in the Union to establish such schools.

THE ORAL METHOD TO THE FRONT

The oral method, however, is gradually coming into the foreground in all the American institutions for the deaf where, formerly, only the sign language was taught and where, of late years, the combined system has been used. On this subject Superintendent E. W.

Walker, of the State Institution at Delavan, Wis., where formerly only the sign language was taught, but now the combined system is used, said:

"At present about 70 per cent. of our pupils are in the oral department, but I think that this percentage is not as high as it should be. It has been a source of great satisfaction to me during the past year to have pupils in our oral department talk and read the lips more; to have an increasing number come to my office and talk, instead of spelling or signing to me. It is a great gratification as I go on the playground to have an increasing number come and talk with me. It is not sufficient that we have a few who talk excellently, and until a very large number,—75 per cent. I will say now, perhaps 80 per cent. in a year or two,—habitually speak and read the lips, we superintendents and teachers have much to do to make our combined system schools what they should be."

And yet, in spite of this acknowledgment of a former instructor in the sign language, there are many educators of the deaf in America who cling to the sign language with a tenacity worthy of a better cause.

"The day for the sign language is past, and, because of its deteriorating tendencies, it is doomed." This is the universal sentiment in the West; it is largely due to the influence of Dr. Alexander Graham Bell and the "Volta Bureau" in Washington, D. C., an institution founded by Dr. Bell "to promote the teaching of speech to the deaf."

"With the English language available for all purposes, and with methods skilfully adjusted to the full utilization of its larger resources and capacities," says the *Association Review,* "the sign language is a thing in the way, and it acts at every stage of education as an encumbrance and a check."

This the prominent educators of the deaf in Europe long ago recognized, and in no school for the deaf is the sign language permitted, except in rare cases of the feeble-minded.

Having been appointed by the School Board of our city to visit the schools for defective children in Europe, I will here relate a few of my experiences and observations in some of the leading institutions of Europe.

THE SCHOOLS OF NORWAY

After living on a Danish steamer for almost two weeks, and associating exclusively with Scandinavian people who assured me that I would have no difficulty in communicating with my colleagues in Norway, I was not a little surprised when, after arriving in Christiania, the voice that answered my telephone call responded in English.

It was Mr. Eyvind Boyesen, Superintendent of the Agricultural School in Sandefjord, who had, a few years before, visited American schools, and who offered to be the general interpreter.

As I was sent to study all lines of special education—not the education of the deaf only—Mr. Boyesen's assistance was highly appreciated, for without this I should not have been able to gain the information I sought.

As in other countries, the beginning of the education of the deaf in Norway was very small. The first public school was erected in 1825, in Drontheim. The first school for the speaking deaf was founded in 1848, in Christiania, and was followed in 1850 by the schools in Christiansand and Bergen.

In 1881 and 1882 three private institutions sprang up: the School for Speaking Deaf, established by Mrs. Rosing in Christiania; Hofgaard's Deaf and Dumb Institute, in Hamar, and Lyng's School for Speaking Deaf, in Drontheim.

This made necessary the compulsory education laws of 1883, providing that the education of the deaf be under government control. In addition, the directors of the different institutions saw that some organization was necessary. Therefore, in 1883, at the Abnorm School Congress, a resolution offered by Director Blomkwist, Cerebro, Sweden, was unanimously adopted; it provided that the deaf be divided into three groups or classes according to their intellectual fitness. Then Denmark organized one "receiving" institution, and Sweden organized seven districts with nine public institutions. According to a recapitulation made by Director Nordin in Wenersborg, the different teaching methods are in the following ratio: the oral method 75.9, the letter-method 18.7, and the finger-method 5.4 per cent.

All pupils are received at the Christiania School, Prof. F. A. Fjortaft, Director, and after a year's trial are classified as A, B, C,

and D pupils. The A pupils remain at Christiania, the B's are sent to Holmestrand, and the C and D pupils to Hamar.

It was the consensus of opinion of the educators that the A, B, and C pupils should be taught by the oral method, and that the D pupils, being feeble-minded, should be sent to asylums, and taught by whatever means would reach them. All the pupils are boarded in the school for four years, then are boarded out in families for another four years, and return to the institution for one year of industrial training.

Besides a complete system of manual training, carpentry, shoemaking, and tailoring are taught. The girls learn to do housework, dressmaking, patching, darning, and the Norwegian handiwork. As the apprentice system is still in vogue, many boys learn their trade as hearing boys do,—under a master.

AGRICULTURAL SCHOOL AT SANDEFJORD

One of the interesting features of the work in Norway was seen at Sandefjord,—the Agricultural School for the Adult Deaf. This school for deaf farmers was established because so many of the deaf live in the country, and farmers carry on their work scientifically.

Agriculture is the chief occupation taught, but in connection with this a technical course in the science of agriculture, stock raising, mathematics, and physiology is given. Other trades are to be added as soon as the government gives more liberal support. To me it seems a very fine beginning, and it is in advance of anything we have seen in this country. The course extends over two years, and then students are supplied with positions. Such agricultural schools for the deaf should be established in every State of the Union. They would be of immense value to the dependent deaf, as no better occupation could be found for them.

In the prospectus of the Agricultural School for the Deaf in Sandefjord is the following statement:

"Since so many deaf children come from the country, we think it would be very practical to build a school for them where they can be taught farming, gardening, and all work in and around the house. In such a course, lasting one or two years, probably ten or twelve scholars yearly could be admitted, say forty to fifty in all, both boys and girls."

This exactly describes the conditions in our agricultural districts in America.

Thirteen young men were taking the course. They spoke very well and read the lips with ease. Only A, B, and C pupils are admitted to the school.

The superintendent believes thoroughly in family life, that it makes the pupils happier, and enables them to associate with the hearing. He does not believe in giving children too many luxuries such as they do not have at home, nor in educating them beyond their station, as they easily become conceited.

Coming from a democratic country where the rich and the poor, the bright and the dull, are all amalgamated in a great melting-pot, this social economic system of placing every child where he or she can be trained to become as useful as possible impressed me greatly. The deaf, the blind, the crippled, the unruly boy or truant, and the incorrigibles, all have a place where they may be trained to become useful members of society.

As I did not know the language, I could not judge as to the technical work done in the schools, but the articulation was so clean-cut and exact that by listening to the children I could repeat their sentences, and use them in conversation. I was understood, and marvelled at such results.

Permit me to take this opportunity of thanking the superintendents of the schools in Christiania and Sandefjord for the courtesy, kindness, and patience shown an American colleague who had the presumption to attempt to study a system of education without knowing the language. But it was of great benefit as well as a pleasure to me, and I feel greatly indebted to them for the information given.

THE SCHOOLS OF DENMARK

Very strict educational laws exist in Denmark for the education of the deaf. Every deaf or partly deaf child in that country must, provided it does not receive private education, go to the School for the Deaf in Fredericia when he reaches his eighth year. Here he remains one year on trial. Then the children, according to their abilities, are divided into four classes, the "figurative" or "improper" deaf, and classes A, B, and C. The figurative deaf are sent to Nyborg, where they remain seven years, receiving instruction after

the oral method. Classes A and B remain in Fredericia, where the oral method is also taught. Class C goes to the Royal Deaf School at Copenhagen, where the pupils are taught after the hand alphabet method.

As the first year in the oral method schools is devoted exclusively to teaching the child to articulate and to instruction in the first exercises of the oral language, the pupil cannot commence his real education in writing, reading, and arithmetic until after the first year.

Since 1896 the Copenhagen institute has had a class for weak-minded children, which makes it unnecessary to send to the "Asylum for the Weak-minded" those children who are capable of being instructed. By permission of the government there are also two small private classes for the deaf in Copenhagen, for children whose parents prefer to have them at home rather than in an institute.

In Denmark and Norway I found the best and most complete economic system of education. Money cuts no figure if the thing is needed. In no country which I visited did I find the question of expense in educational matters coming to the front as in America. New things, if they are needed, are bought or put up, regardless of cost, and in a manner to last for generations.

In Copenhagen is a school for the feeble-minded deaf, for stutterers, and for children with defective speech, each department in a separate building. The asylum for defective hearing is in Nyborg, and is a fine building. If a child needs any operation on its vocal organs, it is done at the expense of the city. For the totally deaf and brighter pupils there is an institution in Fredericia. The oral method is employed in all schools for the deaf, save in the "School for the Feeble-minded Deaf" in Copenhagen, where the manual alphabet is used.

The sign language is tolerated in the lowest classes for the deaf in Denmark; but, owing, it is said, to the energetic opposition of Director Joergensen, of Fredericia, only about one-fifth of the Danish deaf children are taught by the sign language.

As Fredericia and Nyborg are closely connected, there is no difficulty in sending the children home during vacations. A little sign on the breast or cap acquaints the train officers and the passengers with the destination of the little traveller. No child is sent

home, however, until the relatives have notified the authorities that they will meet him at the home station or at any dangerous junction. The fare is paid by the institution. In Copenhagen yearly 15,000 little "vacation tourists" have free rides, *via* railroads and steamboats, when they go home.

Copenhagen also has a "Working Home for Deaf Girls," where they are trained in all kinds of housework, that they may be self-supporting. In addition is a home for girls who cannot find work, or who are unable to support themselves.

Prof. G. Forchhammer, of the Deaf School, has introduced "a new expedient for teaching the deaf." He calls it the "hand-system," and says, "It is our main aid in articulation and in the whole course of instruction." It consists of a systematic set of hand positions which indicate to the pupils the invisible positions of the vocal organs. These hand positions are intended for use simultaneously with oral speech, when they are called "the mouth-hand system." The positions of the hand and fingers are similar to the sign or finger language still used in some institutions in our country. The position of each finger represents a sound. They also use what they call "phonetical writings" to aid in securing the correct pronunciation of written words. Both of these methods, Professor Forchhammer states, have proven to be of great value in the instruction of the deaf, enabling the pupil to pronounce words more clearly and distinctly.

"Bonet (1620) and Amman (1692)," says Professor Forchhammer, "created the articulation method, and they have had a clearer conception of it than many modern teachers of the deaf."

In Professor Forchhammer I found a most interesting, intelligent man, whose conversation I greatly enjoyed. I received the same impressions in Christiania, Sandefjord, Copenhagen, Fredericia, and Ascot. Judging from the royal treatment I received from the school authorities wherever I went, the Scandinavians are to be classed as a most refined, amiable, and hospitable people.

THE SCHOOL AT COPENHAGEN

The Danes make very generous provision for every child. The poor are clothed by the State, even while they are learning a trade, and meals are provided for the poor in the public schools. The

Copenhagen school is "internate." * The pupils eat five times a day; besides three regular meals, bread and beer are served at five o'clock, and bread and milk at eight.

A complete system of manual and physical training has been instituted, and in a separate building are classes for stutterers and stammerers and those with other defects of speech.

An opportunity was given me to see the wonderful results of operations on the organs of speech and on the mouth by experts at the expense of the State or city. One child had an artificial palate which was so skilfully placed that very little defect in speech was noticeable; another had his jaw transformed, so to say: certainly evidence of the skill of the Danish surgeons.

An interesting feature, not seen elsewhere, was the "Home for Friendless Girls." This institution is endowed and partly supported by the State. The girls take a course of two years in fancy work, sewing, and laundry work, and, after their apprenticeship, receive compensation. The work is done so well that the girls cannot supply the demand. When they become old, they may enter the "Asylum for Old and Helpless Deaf Women." At the time of my visit, there were ten old women in the Asylum and 31 inmates in the Girls' Home.

An "Asylum for Dependent Men" is established in connection with the Agricultural School at Nyborg. Fourteen acres of land were donated by the city, and the deaf of the whole country contributed the buildings. Imagine this wonderful system of economics in Denmark!

The 14 acres produce annually $3000, $1000 of which is used for school expenses, $1000 for family expenses, and $1000 is saved. When visitors expressed surprise upon hearing that one-third is laid aside for old age they were told that this was quite customary in Denmark.

* Pupils are boarded in the institution.

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